IMPERIAL BUREAU OF HORTICULTURE AND PLANTATION CROPS

TECHNICAL COMMUNICATION No. 13

VEGETATIVE PROPAGATION OF TROPICAL AND SUB-TROPICAL PLANTATION CROPS

Compiled by

G. ST. CLAIR FEILDEN, B.A.

Drawings of propagation methods and accompanying descriptions by

R. J. GARNER, N.D.H., DIP.HORT.SCI.,
East Malling Research Station

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In this long-promised sequel to Technical Communication No. 7* an attempt has been made to collect and set down all available information on the vegetative propagation of plantation crops.

One or two minor fruit crops omitted from the previous compilation are also included.

The only change in arrangement of subject matter is that the references in Technical Communication No. 13 are given after each crop instead of all together at the end.

Comments and fresh information on any points raised in either of these two compilations will be welcomed.

* Vegetative propagation of tropical and sub-tropical fruits. *Tech. Commun. imp. Bur. Fruit Prod.* 7, 1936, 2s.

VEGETATIVE PROPAGATION OF TROPICAL AND SUB-TROPICAL PLANTATION CROPS

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FOREWORD

By Sir Geoffrey Evans, C.I.E.

Four years have elapsed since I wrote a foreword to Technical Communication No. 7 of the Imperial Bureau of Fruit Production, which dealt with the vegetative production of tropical and sub-tropical fruits. Mention was then made that a further Memoir dealing with the vegetative propagation of perennial tropical and sub-tropical crops other than fruit trees would follow and this publication, which is by the same authors as the previous Memoir, is now presented.

As stated in the title, the subject matter is plantation crops, but it is evident that this term is a wide one and covers a somewhat extensive range. It is probably on this account that certain genera, such as *Lecythis*, which produce the excellent Sapucaia nuts, are discussed, although they really come under the category of nuts, of which, for example, the Macadamia or Queensland nut was included in the previous volume, as also the Cashew nut and others. Incidentally, the Brazil nut, *Bertholletia excelsa*, is not discussed in either volume and it is presumed that little or no work on the vegetative propagation of this tree has yet been published. Although it is of great economic importance, it is not yet cultivated systematically as a plantation crop and has not therefore been the subject of detailed study.

This example serves to illustrate how much remains to be done in the field of tropical economic crops and how great is the field for investigation and research.

A study of this volume will indicate the great range of crops that have been covered by the authors and the immense amount of study they must have undertaken in the process of compiling these records.

In some of the major crops, such as tea, cinchona, rubber and coffee, work on methods of vegetative propagation has been going on for a number of years and the knowledge acquired is already very considerable. These crops are of international importance and the value of the investigations is widely recognized. Other major crops, such as cacao, have been comparatively neglected until recently, but already a great deal of information in the special technique of vegetative propagation for this crop in particular has accumulated. Again, other crops have had little attention devoted to them as yet but are now being considered. Vegetative propagation is a natural sequel to the work of the geneticist and the plant breeder. The latter may be able to select plants possessing desirable characters, such as high yield, good quality or resistance to disease, but very often such plants if propagated from seed do not come true to type owing to heterozygosity, and ways and means of propagating them vegetatively have, therefore, to be perfected. A new commercial crop which has presented difficulties of this sort is *Aleurites* which produces tung oil. This plant is presenting many interesting problems and, if the attempts that are being made to cultivate it as a plantation crop are to succeed, high yielding clones will have to be vegetatively produced. Other crops again are proving very difficult, as for example the nutmeg, in which the male and female flowers are born on separate trees, and where it would obviously be a great advantage to be able to plant areas with trees of known sex.

The compilation of this volume with its record of experimental results on such a variety of crops, of which it has only been possible to mention a few, should, therefore, prove of the greatest value to investigators in this particular branch of work. Of particular value is the

account of the different methods of budding, grafting and rooting cuttings. The illustrations have the great merit of simplicity, being clear and easy to follow. This section is really a repetition of a similar one published in the former volume, but it has been brought up to date and has many useful additions, such as the description of basket-making, as practised in the West Indies. These baskets have proved of great practical value in moving certain plants that are otherwise difficult to transplant.

Little mention is made of the use and value of growth producing substances as an aid to the rooting of cuttings, except under the section dealing with coffee. It is possible that in a future edition, a fuller account of the use of these substances as affecting the more important crops might be included, but it may, of course, be argued that this subject is now being fully dealt with in separate publications dealing specifically with these problems.

The authors and the officers of the Bureau of Horticulture and Plantation Crops are to be congratulated on the successful production of this Memoir, which will undoubtedly prove of great assistance to workers in this branch of crop production throughout the tropical parts of the world.

G.E.

9th March, 1940.

Royal Botanic Gardens,
Kew.

METHODS OF VEGETATIVE PROPAGATION

In order to avoid ambiguity and to reduce explanation to a minimum, a description, frequently accompanied by an illustration, has been given at the beginning of the communication of each type of budding, grafting or other vegetative propagation method mentioned suitable for dicotyledonous plants. There should thus be no doubt as to what is meant when these terms are encountered in the text. Special modifications of a standard method to meet the needs of a particular variety are described under that variety.

Monocotyledons require treatment for which no general rules can be made, since it varies with each genus. Where plants of this nature are under discussion the methods are there described in full.

It should not be assumed that, because any given method of propagation is not mentioned for a particular tree, the method is unsuitable. The method will have been omitted because no records of it are available. It is more than probable, for instance, that the etiolation method of rooted shoot production and the modified Forkert method of budding may prove successful with a number of trees on which they have not yet been tried.

The term " budding " implies shield budding unless otherwise qualified.

Where no specific rootstock is mentioned it is because information is not available. In such a case the same species as the scion can be surmised.

INCOMPATIBILITY.

Some notes on incompatibility from the work of W. T. Chang at East Malling may be of interest.*

" With all incompatible combinations, grafted or budded, there were marked symptoms of a low percentage take, premature autumn leaf-coloration and flower bud formation, early defoliation, and dying back of young shoots. The low percentage take was less noticeable on budded than on grafted plants. In all incompatible combinations there was a marked gradual decline of the annual wood growth, usually following an initially vigorous growth at an earlier stage. There was also a gradual decline of new root growth both in number and length. The incompatible combinations started new root growth much later in the spring than the compatible ones. All incompatible combinations showed a mechanically weaker union than the compatible ones. This was indicated by : (*a*) bark and wood-fibre discontinuity ; (*b*) heavy accumulation of parenchymatous cells at the union ; (*c*) reduced strength at the union and clean surface of break. Incompatible combinations had some form of obstruction at the union. This was indicated by : (*a*) slower flow of dyes through the union as shown by dye injections ; (*b*) a much higher resistance to the flow of water ; (*c*) a heavy deposit of starch above the union in November. Some of the physiological functional differences between the scion and its incompatible stock have been studied. It was found that different stock and scion varieties had : (*a*) different periods of cambial activity ; (*b*) different periods of callus growth and different regions of callus differentiation, as studied in grafts ; (*c*) difference in the duration of leaf-expansion from the time of bud-break, the combination being most incompatible when a slow leaf-expanding scion was worked on a quick leaf-expanding stock ; (*d*) difference in growth curves, as shown by the weekly measurements of the terminal shoots. It is concluded that a mechanically weak union and the increasing obstruction at the union are the immediate causes of shoot and root decline in an incompatible combination, and that all the physiological functional differences manifested in cambial activity, callus growth, duration of leaf-expansion, and growth curves of the stock and scion varieties may be

* Chang, W. T., 1938. Studies in incompatibility between stock and scion, with special reference to deciduous fruit trees. *J. Pomol.*, 15 : 267-325.

accounted as important contributory causes of incompatibility among deciduous fruit trees. It is pointed out that all these physiological functional differences in the growth activities of the stock and scion are inherent, and may be somewhat modified under different climatic and environmental conditions."

POLYEMBRYONY.

Certain plants produce polyembryonic seeds, that is seeds which contain several embryos, only one or possibly none of which is the result of fertilization, the others arising from cells outside the embryo sac and being thus a form of vegetative seedling. If, after germination, the generative seedlings can be distinguished from the vegetative seedlings and eliminated, a pure line of vegetatively-produced descendants should result. The modern practical application of this theory to citrus selection is fully discussed in Technical Communication No. 3 of this Bureau (*see list on cover*).

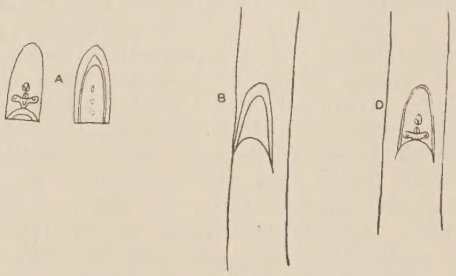
BUDDING.

Bud wood. Petioled and Unpetioled.

By *petioled* bud wood is here meant that wood of which the leaves can be cut off close to the bud at the time of budding, leaving a small projecting stub. By *unpetioled* bud wood is meant that bud wood from which the leaves must be cut off about two weeks before it is taken from the tree. This in due course will cause the petiole stubs to abscis, leaving a healed scar underneath which cannot serve as a point of entry for disease.

Chip Budding.

With deciduous trees the operation is normally carried out just before the stock begins active growth in the spring, using buds taken from dormant bud wood collected previously.



CHIP BUDDING

The scion is prepared by cutting from half to one inch above the bud, passing the knife downwards under the bud, just entering the wood, until the cut is about half an inch beyond the base of the bud, when the knife should be withdrawn. The bud (A) is removed by a second slanting cut which begins immediately below it and continues until it meets the lower extent of the first cut.

Similar cuts are made on the stock (B) to fit the bud. These cuts should be so made that the cambia of stock and scion are in contact on all sides or at least at the top end of the cuts and on one side. The bud (D) should be tied firmly and all cut surfaces should be sealed.

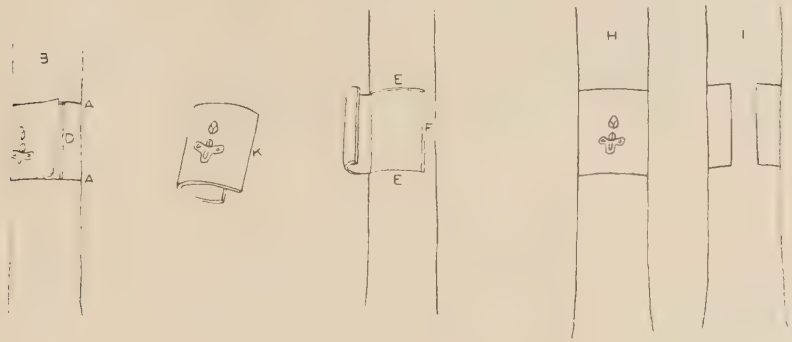
Flute Budding. Modified Patch Budding.

This is sometimes used when shield budding and similar methods fail to give satisfactory results.

For ease of manipulation the stock and scion should be of approximately the same size and age and should be in such a condition that the rind parts readily from the wood.

The scion bud is prepared by making two horizontal parallel cuts (A) encircling the bud-wood (B) through the rind down to the wood. This operation is facilitated by the use of a knife having two parallel blades. A vertical cut (D) connects the two horizontal cuts and enables the bud to be removed. If the horizontal length of the

bud patch is more than sufficient to encircle some seven-eighths of the stock, it should be shortened by a vertical cut removing the required amount of surplus rind. This will avoid completely girdling the stock (ring budding) when fitting the bud patch, and, if the bud dies, the head of the stock will be saved.

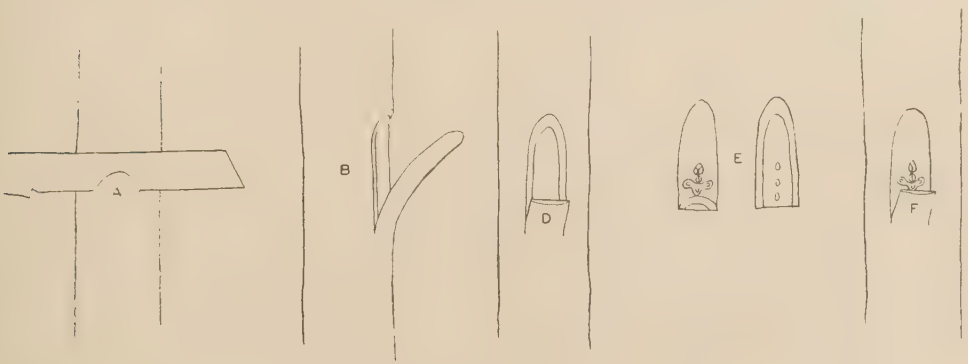


Flute or Modified Patch

Similar horizontal cuts (E) are made almost completely round the stock and a vertical cut (F) enables the rind to be raised from the wood. The vertical edge (K) of the rind patch carrying the bud is placed against the corresponding cut edge (F) of the stock. The rind of the stock between the horizontal cuts is then peeled back until the bud patch fits the stock. The raised rind of the stock is removed by a vertical cut to coincide with the edge of the bud patch. Opposite sides of a budded stock are shown at (H) and (I). Tying completes the operation.

Forkert and Modified Forkert.

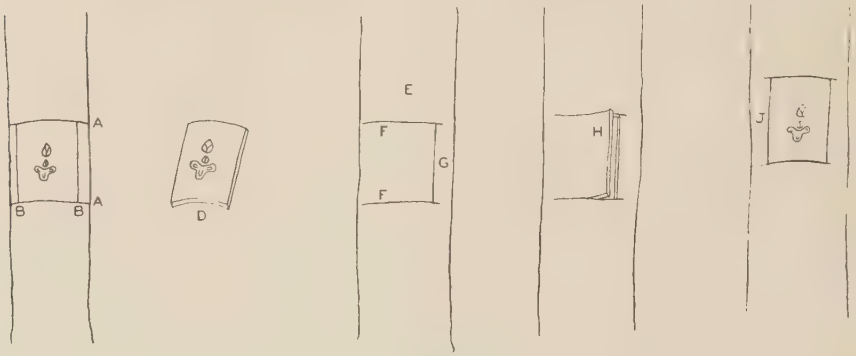
This latter method is the form of budding which has practically superseded all others in the Dutch tropical possessions. A transverse incision (A) is made in the bark of the stock as far as the cambium, and the bark is then peeled down to a depth of about an inch with a width of about one-third of an inch (B). The bark may peel in one or several strips. Two-thirds of the flap thus formed are cut off transversely (D). The bud (E) cut to fit the stripped portion is pushed under the remaining portion of the flap (F) and tied with raffia. In the ordinary Forkert method, which is now considered to be less satisfactory, the bark is cut instead of peeled. It is, therefore, less easy to judge whether the stock is in suitable condition for budding.



Forkert Method

Patch Budding.

By the use of a knife having two parallel blades, cuts (A) are made horizontally around the bud wood through the rind above and below the selected bud. Two vertical cuts (B) made with a single blade connect the horizontal cuts, and the patch (D) containing the bud is removed. The stock (E) receives similar horizontal cuts (F) slightly longer than the width of the patch. A single vertical cut (G) enables the rind to be raised and peeled back (H) so that the bud may be placed in position. The stock rind is peeled back a distance equal to the width of the bud. A vertical cut (J) removes the surplus stock rind, and all exposed edges of stock rind and patch are in contact. Tying completes the operation. In some cases it appears to be an advantage to seal the exposed cut surfaces.



Patch Budding

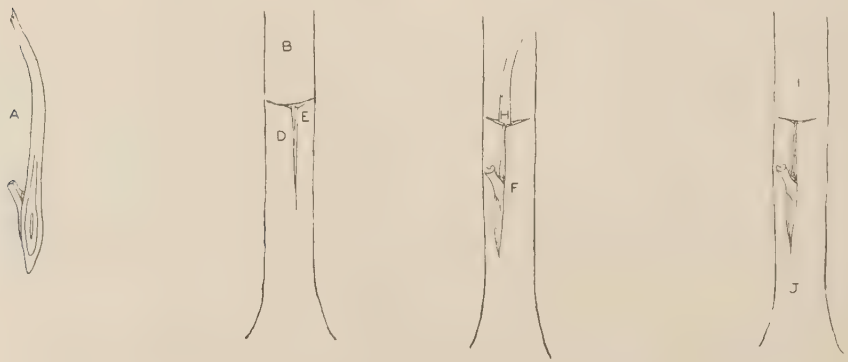
Ring Budding, *see* **Flute Budding,**

the difference being that in ring budding the stock is completely girdled.

Shield Budding.

This is one of the commonest methods of budding and is most easily employed where the portion of the stock to be budded is not more than two or three years old, or where the rind is not so thick as to cause manipulation difficulties.

Shield budding is normally carried out during the height of the growing season when the rind parts readily from the wood of the stock.



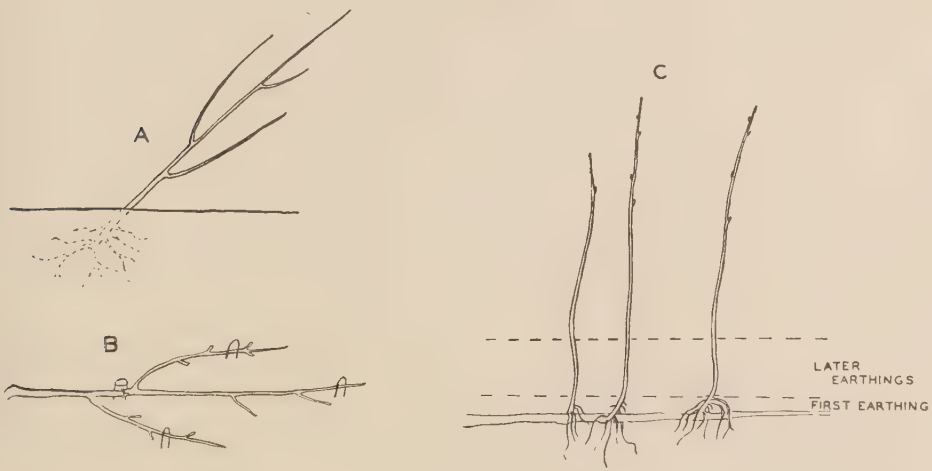
Shield Budding

The scion buds are usually taken from shoots of the current season's growth where they exist in the axils of the leaves. The bud is removed from the bud wood by a shallow slicing cut which commences half to one inch below the bud (*see* note), passing under the bud and coming out well above it (A). If the knife blade be arrested before it quite attains the surface at the finish of the cut and the removal of the bud patch is completed by tearing, the patch will terminate in a long strip of rind which makes a convenient handle. It can be cut off after the bud is inserted (H). With some subjects the portion of wood underlying the bud may be removed from the bud shield before inserting the bud beneath the rind of the stock. The stock (B) is prepared by making a T shaped incision (D) through the rind down to the wood. The rind is raised (E) and the bud inserted (F).

NOTE.—If the inverted T is employed, the cut begins above the bud and passes in the reverse direction.

ETIOLATION METHOD.

This is essentially a form of layering. Young plants of the variety to be layered are set (A) at an angle of 45 degrees in rows 5 feet apart. The distance between the rows is designed to allow for the future drawing up of enough soil from between the rows to cover the layer beds to a depth of 6 inches. The plants in the rows are spaced so that they will form a continuous line of shoots when laid down. When the plants are well established (an important point), they are pegged down flat (B) in shallow trenches along



ETIOLATION METHOD

the rows. With deciduous trees this is done in the dormant season. Immediately before bud break the whole plant is covered with fine soil to the depth of one or two inches only in the first instance and more earth is added as the shoots push up, until the bases of the shoots are covered to a depth of from 3-4 inches, the mound finally reaching a height of 6-8 inches around the stem (C). The lower part of the shoot is thus always kept in the dark and so becomes etiolated. In the case of many subjects this blanched portion will put out roots with more or less freedom according to the variety. At the end of the growing season the rooted shoots are removed and planted out, sufficient numbers being left on the parent plant to form future layers. Thus the bed once established becomes more or less permanent and a constant supply of young plants can be obtained. This, briefly, is the method adopted in raising rootstocks of

certain deciduous fruit trees at East Malling. It can, of course, equally well be applied to trees which it is desired to establish on their own roots.

With the evergreen trees of the tropics, which are seldom completely dormant, certain modifications have been found necessary. The technique is being very thoroughly investigated by the Agricultural Department of Malaya, and we are indebted to them for the trouble they have taken to supply us with much valuable information. They found that with evergreen trees the layered branches died back if covered with soil too early, but that, if the shoots were allowed to grow several inches before being earthed up, this did not occur. At East Malling it is considered important that at no time should the portion of the shoot to be etiolated be exposed to light after growth has started. In many cases rooting has been greatly assisted by binding a wire round the stem of the shoot near its junction with the parent plant. The wire is not adjusted tightly enough to injure the bark at the time, but as the shoot swells the wire slowly penetrates the bark without causing open wounds and provides a stimulus to root formation. Oppenheim,* who used this wiring method with citrus in Palestine, says that with cuttings the roots, though they start above the callus, grow downwards between the bark and the wood and only become visible after penetrating the callus. In wire-bound shoots the roots grow directly through the bark above the ring. There appears to be considerable difficulty in establishing rooted shoots in bamboo pots. The bamboo joint is far from being an ideal receptacle but it is cheap and unbreakable and takes up little space in transit, and is, therefore, useful when plants have to be distributed to various parts of the country, and, of course, cheap distribution of economic plants is one of the important functions of many Agricultural Departments. Plants are more easily established in clay pots, probably owing to better aeration.† Professor Cheesman of the Imperial College of Tropical Agriculture, who has kindly commented on the MS., suggests that the use of palm leaf or other cheap baskets (see p. 20) such as are used in nursery work in the tropics might have the advantages of clay pots without their expense. Delayed etiolation is employed in what is known as the stooling method. This method is worth trying with tropical plants which do not respond to layering. In it the plants to be propagated are cut back to ground level and the fresh vigorous growth which should result is etiolated by heaping earth around it as it grows. At East Malling the earth is first drawn round the plants (apple stocks) when the new shoots are three or four inches long, further additions being made from time to time. The shoots should never be buried to more than half their length.

GRAFTING.

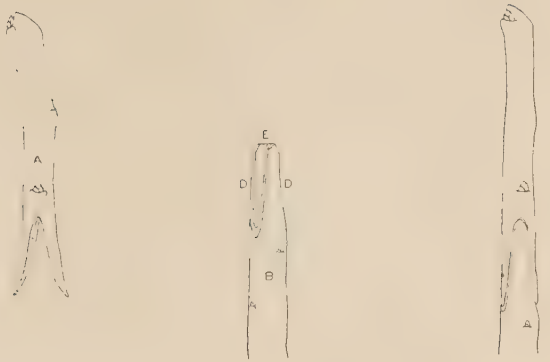
Approach Graft, *see* **INARCHING.**
Bark Graft, *see* **TOPWORKING.**
Bastard Saddle Graft, *see* **Strap Graft.**
Cleft Graft, *see* **Wedge Graft.**
Crown Graft, *see* **TOPWORKING.**
Rind Graft, *see* **TOPWORKING.**

Saddle Graft.

The stock and scion should be approximately the same size. The scion is prepared by cutting upwards through the rind and into the wood on opposite sides of the scion piece. The knife should penetrate more deeply into the wood as the cuts are lengthened and, before the knife is withdrawn, turn sharply towards the middle of the scion so that the middle portion may be removed and the scion (A) have the required saddle formation. The stock (B) is cut transversely and receives two upward cuts (D) on either side

* Oppenheim, J. E., 1932. A new system of citrus layers. *Hadar*, 5 : 2-4, fully abstracted in *Hort. Abstr.*, 2 : 162.

† Lambourne, J., 1935. Progress report on etiolated shoot method of propagation up to September 1935. Communication from Director Agric. F.M.S. and S.S.



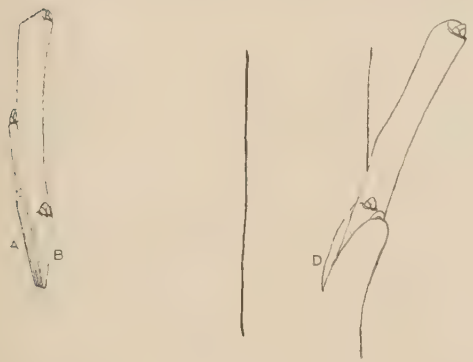
Saddle Graft

sufficiently deep to expose the cambia in such a position that they may match those in the saddle of the scion. The apex (E) of the stock is shaped to fit the saddle. Stock and scion are fitted together and firmly tied. All exposed cut surfaces are sealed.

Side Graft.

An alternative method to Side Tongue Graft.

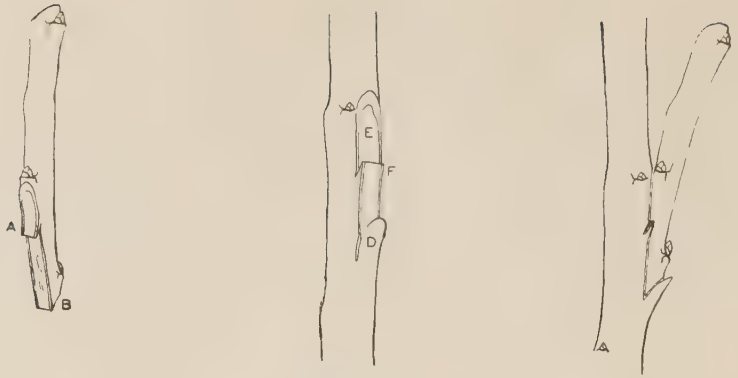
Two slanting cuts, one (A) slightly longer than the other (B), are made at the basal end of the scion at opposite sides to form a gradually tapering wedge. An incision (D) is made in the side of the stock at an angle of approximately 20 degrees and of sufficient depth to allow for the insertion of the above-mentioned wedge. The longer side of the wedge is placed against the stock stem in such a position that the cambial regions of stock and scion are in contact. By bending the stock, so that the incision (D) is opened, the scion may be pushed home more readily. All exposed cut surfaces are sealed. Provided the incision (D) is made sufficiently deep into the wood of the stock, the scion is firmly held and tying (but not sealing) is unnecessary: otherwise the graft should be tied firmly.



Side Graft

Side Tongue Graft.

This is employed when it is required to place the scion on the stock without heading the stock back to the position of the graft union. This graft is likely to be very successful when the diameter of the scion is slightly less than that of the stock, and it can be used also when the scion is very considerably smaller than the stock. A long, flat, slanting cut is made at the basal end of the scion. A downward pointing tongue (A) is made in the slanting surface. A short cut (B) is made on the opposite side to form a chisel-shaped base to the scion. An upward pointing tongue (D) is cut in the stock to hold the base of the scion. A downward cut (E) is made as far as the tongue (D)

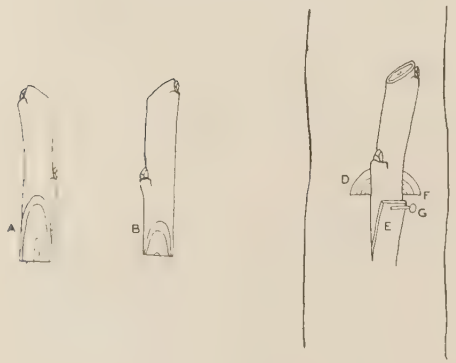


Side Tongue Graft

to expose the cambial regions in such a position that they correspond to those of the prepared scion. A tongue (F) is made to interlock with that of the scion. The tongue (D) covers the chisel-shaped base of the scion (B). Stock and scion are bound together and the exposed cut surfaces are sealed.

Slotted Side Graft.

Used when the stock is considerably thicker than the scion. The scion is prepared with its basal end in the form of an unequally-sided wedge (A and B). The stem or branch to be grafted receives a downward cut penetrating to the wood. A transverse cut at the base of the downward cut produces a step (D) in the side of the stock branch. Two parallel cuts, very slightly closer together than the width of the scion, are made downwards from the transverse cut. These two cuts should equal the length of the longest slanting cut of the scion. The rind (E) between the parallel cuts is raised slightly and the scion, with its longer cut surface towards the branch, is pushed down under the raised rind until the whole of the tapered base of the scion is below the level of the transverse cut (F) on the stock branch. A gimp-pin or brad (G) is driven through the upper part of the raised rind, through the scion and into the wood of the stock. All exposed cut surfaces are sealed with wax or similar material.



Slotted Side Graft

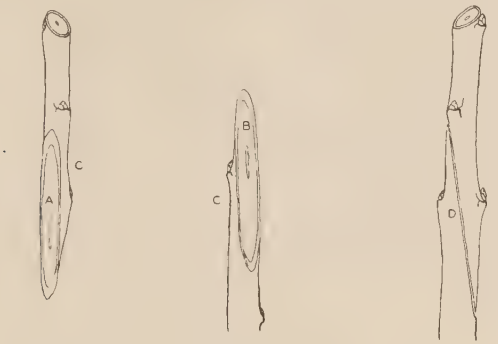
Somerset Saddle Graft, *see* **Strap Graft.**

Splice or **Whip Graft.**

This is one of the simplest methods of grafting stocks and scions of the same diameter. (*See* also Whip-and-Tongue Graft.) A long slanting cut (A) is made at the basal end of the scion. A corresponding cut (B) is made at the apical end of the stock. The cut surfaces are placed together (D) so that the cambial regions (C) are in contact.

When the rind of the scion is considerably thicker or thinner than that of the stock, the matching of the cambial regions brings the surfaces of the rind out of alignment, but this is of little consequence.

Stock and scion are bound together and the exposed cut surfaces are sealed.

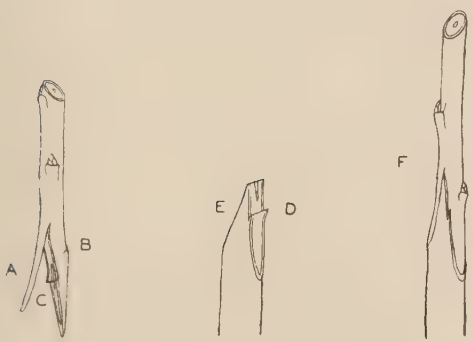


Splice Graft or Whip Graft

Strap or **Bastard Saddle** and **Somerset Saddle Graft.**

The scion is prepared by first raising a strip (strap) of bark (A) with a small amount of wood upon the scion-wood opposite a bud (B). The knife is reversed and a slanting cut as long or longer than the strap is made through the scion-wood to a point an inch or so below the bud. A tongue (C) is raised mid-way along this second cut surface. If the tongue is omitted, the graft is known as the Somerset Saddle Graft.

The head of the stock is removed by a long slanting cut (D) and a second but shallower cut (E) is made on the opposite side to form an upward pointing, unequally sided wedge. A tongue is raised upon the surface of the first cut on the stock to correspond to the scion tongue. Stock and scion are fitted together (F), firmly tied and the cut surfaces are sealed.



Strap or Bastard Saddle Graft

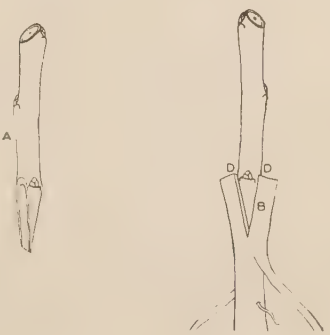
Veneer Rind Graft, *see* **TOPWORKING.**

Wedge or **Cleft Graft.**

This is often used when scions are grafted directly on to portions of roots. The scion may be of the same or less diameter than the stock. The rind of the root is usually considerably thicker than that of the scion, and in cases where stock and scion appear to be of equal diameter it will often be found that the two cambia are not really coinciding, a condition which may result in failure of the graft.

The scion (A) is prepared with its basal end in the form of a wedge.

The stock is split at its apical end (B) and the scion should be inserted so that the apical



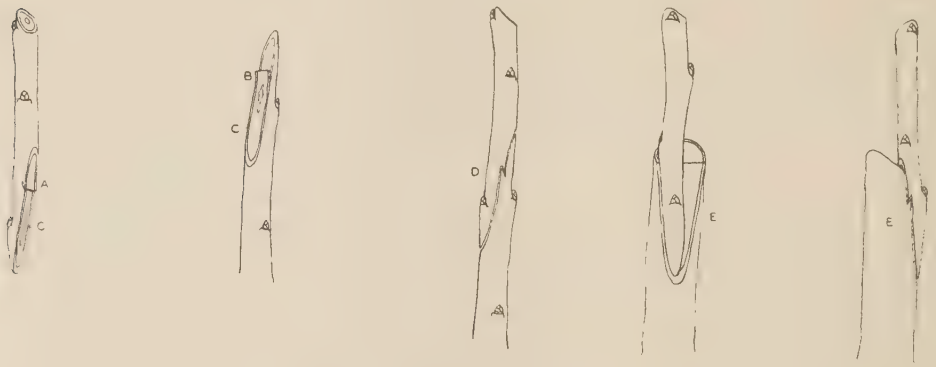
Wedge Graft

portions (D) of the cut surfaces of the scion are just visible and so that at least one side of the cambia of stock and scion are in contact.
The graft requires tying and sealing except where it is possible to obtain a union by placing the graft in moist material.

Whip Graft, *see* **Splice Graft.**

Whip-and-Tongue Graft.

This method is used when the scion and stock are comparatively small, not more than one inch in diameter. It is similar to the splice graft except as regards the tongue which serves to hold stock and scion together so that the operator has both hands free for tying. Whip-and-tongue grafting is employed to best advantage when stock and scion are of equal diameter. If the stock is considerably larger than the scion it is only possible to match one side of the scion with one side of the stock (E) in such a manner that the cambial regions are in contact.



Whip-and-Tongue Graft

A flat slanting cut, the length of which is approximately six times the thickness of the scion, is made at the basal end of the scion. A downward pointing tongue (A) is made in the apical half of the slanting surface. A slanting cut, corresponding in length to that of the scion, is made upwards through the stock. An upward pointing tongue (B) is made in the apical half of the slanting surface. The cut surfaces of the scion and stock are placed together so that the tongues interlock (D) and the cambial regions (C) are in contact over as great a length as possible. Tying and the sealing of all exposed cut surfaces completes the operation.

INARCHING or **APPROACH GRAFTING.**

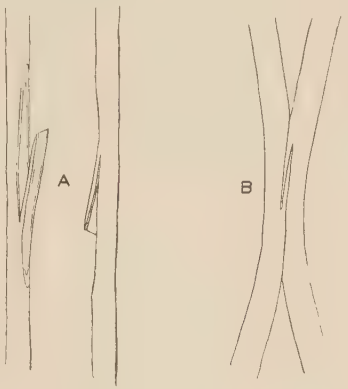
In this process the scion remains on the tree until union is complete. The stock is grown or transplanted into a pot which is brought near to the scion by some such means as a platform built under the tree at a suitable level on which the pots are stood, or by insertion of the pot in the cleft end of a bamboo pole. To make the graft the bark and part of the wood of both stock and scion are sliced off for two or three inches along the stems of the stock and the scion. The cut surfaces of stock and scion are then brought together so that the cambia of each are in contact and they are bound in that position by a wrapping of waxed cloth. It is preferable that stock and scion should be of the same thickness. When union is complete, the scion should be severed from the tree in three or four stages at intervals of a week. At no time should the pots be allowed to become dry.

Tongue-Inarching, English Approach-Grafting or **Approach-Grafting with a Tongue.**

In this method the scion remains on the parent tree until union with the rootstock has taken place. The process is more conveniently carried out when stock and scion are of similar thickness.

Deep slices of bark and wood three or four inches long are removed from both scion and stock in order to expose the cambia equally. One inch from the top of the cut surface on the stock a cut is made downwards to form a tongue of two inches. A similar tongue is made upwards on the scion (A). Stock and scion are brought together (B), tied firmly and sealed. Independent movement of stock and scion must be prevented.

When union is complete, the scion should be severed from the tree below and the head of the stock removed from above the union in three or four stages.



Tongue Inarching

LAYERING. (*See also* **ETIOLATION METHOD.**)

This can be practised with branches sufficiently low on the ground or the layers may be made in pots of earth standing on raised platforms or in earth spread on the platforms. Rooting and after-growth are slow and the method is not to be recommended except in special circumstances. The layers must be kept watered.

MARCOTTING.

Also known as the gootee method, or air layering.

The selected branch is first girdled at the point at which roots are required, a strip of bark about an inch wide being removed. The girdled part is then, either immediately or in a day or so after the formation of a callus, packed with a ball of some rooting compost which may, for instance, consist of a mixture of soil, leaf mould, well rotted cow manure and sand with an outer wrapping of sphagnum moss or other moisture-holding material bound over the whole.

In countries where there is a sufficient rainfall the rooting medium will be kept sufficiently moist ; failing that, it must be watered at intervals. An ingenious method of securing a continuous supply of moisture without much trouble is that in which a bamboo joint containing water is suspended above the marcot. From a hole in the bottom of the joint issues a string which is attached to the bandage, and thus by a slow but continuous percolation of water along the string the marcot is kept moist.

TOPWORKING.*

The practice of grafting established trees which involves the removal of most of the branch system of the trees is termed topworking. The methods commonly employed may be classed under two heads : (*a*) cleft grafting (sometimes known as split or wedge grafting) and (*b*) rind grafting (sometimes termed bark or veneer grafting).

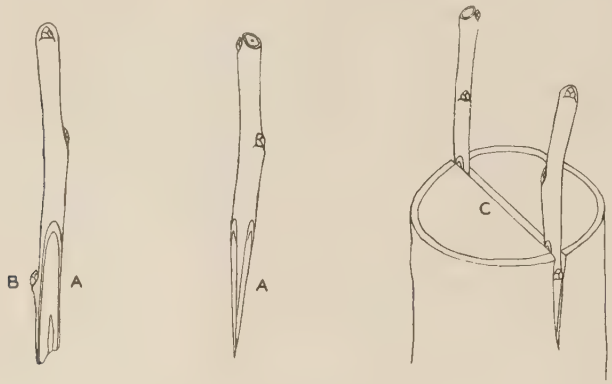
Bark Graft, *see* **Rind Graft.**

Cleft or **Wedge Graft.**

The base of the scion is prepared by two slanting cuts in the form of a long tapering wedge (A). The presence of a bud (B) between the two cut surfaces and about half-way between the point at which the cuts begin and the base of the scion is an advantage.

* For frameworking, an improved system of topworking, *see Occas. Pap. imp. Bur. Hort. Plant. Crops* 5, 1938, 1s.

The stem or limb to be grafted is cut off at the point at which it is proposed to graft and the surface is pared smooth with a knife. If the limb is to receive two scions it is cleft diametrically. This cleft is opened by the insertion of a wedge or by using the grafting tool as a lever. The scions are inserted so that their cambial areas are in contact with those of the stock. The wedge or tool is removed and the scions are held fast by the pressure of the limb of the stock (C).

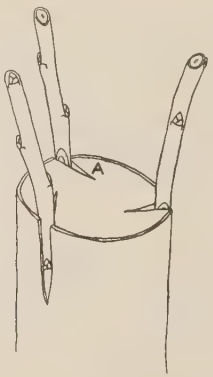


Cleft Graft

Should only one scion be inserted in the end of each limb it is unnecessary to extend the cleft right across the limb. It should extend only half-way across and should be sufficiently deep to allow for opening and the insertion of the scion.

Oblique Cleft Graft.

A modified cleft graft is that known as the oblique cleft. In this method the limbs of the stock are cleft tangentially (A) or rather along chords of the transverse section of the



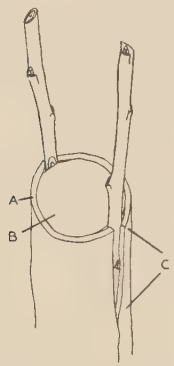
Oblique Cleft Graft

limb. The clefts do not extend more than half the length of the chord. They are opened by means of the grafting tool and the scions are inserted. Removal of the tool causes the scion to be held firmly in position. Numerous scions may thus be inserted in one limb as required. Scions are prepared as for ordinary cleft grafting.

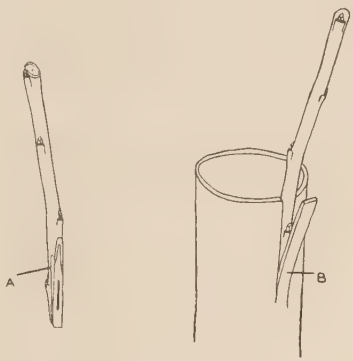
Crown Graft, *see below.*

Rind Graft, Bark Graft or **Crown Graft.**

In rind grafting the scion is inserted between the rind (A) and the wood (B) of the tree. With all types of rind graft it is essential that the rind of the stock should part readily from the wood. In the most common method the scion is prepared as for splice-grafting. The limb of the stock is cut transversely at the point at which it is proposed to graft. The rind of the stock receives a cut (C) of one or two inches in length extending downwards from the end of the transverse cut, and the prepared scion is pushed down beneath the rind so that the cut surface of the scion is towards the middle of the limb. Large limbs receive three or more scions. Unlike the cleft graft this rind graft must be tied firmly in order to retain the scions in position.



Rind Graft (Bark Graft)



Veneer Rind Graft

Veneer Rind Graft.

In the veneer type of rind graft the scion is prepared as for normal rind grafting except that thin shavings (A) are removed from the edges of the cut surfaces in order to expose the cambial areas.

The transversely cut limb receives two parallel cuts sufficiently wide apart to fit the prepared scion. The scion is pushed down beneath the rind lying between the parallel cuts. The surplus rind (B) is pushed outwards during the process and is cut off close to the grafted limb. The graft requires tying.

In all methods of top grafting the exposed cut surfaces should be sealed after completion of the graft.

GRAFTING WAX.

The following recipe for grafting wax for use in the tropics is, by kind permission of the author, taken from Hawaii Agricultural Experiment Station Bulletin No. 59, 1929, " The Macadamia Nut in Hawaii ", by W. T. Pope :—

The materials required are by weight 1 part tallow, 8 parts beeswax and 4 parts resin. " Melt the tallow in a suitable iron kettle over a slow fire ; then add the beeswax. As soon as the mixture begins to boil add the resin gradually, stirring continuously until it melts. Continue the boiling for five minutes, then remove the kettle from the stove and pour the liquid through cheese cloth into a large container of cold water. When the mixture has thoroughly cooled, work it with the hands until it becomes tough and doughy. Thorough cooling is very important to prevent lump formation. Kneading may be difficult at first, but becomes comparatively easy after a few moments. To

prevent the wax from adhering to the hands grease them slightly with tallow. As soon as the wax assumes a creamy, silken colour it may be worked into rolls about 2 inches in diameter and 5 inches in length, then wrapped in waxed paper. The wax is then ready for immediate use, or it may be stored for future use. If it hardens, knead in a very small amount of tallow."

BUD DRESSINGS.

Experiments at East Malling* involving 1,600 buds showed a 25 per cent. increase in bud-take following treatment with petroleum jelly. The jelly was smeared by means of the finger over the tied bud so that the bud and all cuts in the bark were completely covered. One pound of jelly was sufficient to treat more than 1,100 buds.

GRAFTING TAPE.

In Trinidad this is made by dipping plain cotton tape into hot beeswax to which a little antiseptic such as creosote has been added. The tape is cut into 10-inch lengths and stored till required. Before use it is drawn through the fingers to make it adhesive. This tape effectively excludes water from the part covered. It can be used more than once.

Another method of preparing this is to wind strips of cotton cloth on a stick until the roll attains a diameter of about an inch and then to plunge it in melted wax until saturated (i.e. for about 20 minutes). The wax is prepared by melting together (not boiling) equal parts of beeswax and resin.

Another recipe for wax is to melt together 1 part tallow (by weight), 2 parts resin, 4 parts beeswax.

TYING MATERIAL.

In experiments at East Malling,† rubber strips as ties in shield budding have always given increased bud-take in comparison with raffia ties.

A METHOD OF SOFTENING THE STOCK BARK.‡

The tough or brittle bark on old stocks can often be softened sufficiently for budding if the surrounding ground is first well watered, reduced to a fine tilth and drawn up round the stock to a height of about 6 to 8 inches. About 6 weeks later the earth may be withdrawn and the stock budded.

POTTING BASKETS.

In Trinidad and in the Botanic Gardens, Georgetown, British Guiana, a loosely woven basket is used for potting seedlings, cuttings, etc. requiring special care. The baskets are cheap to make. On transplanting to the permanent site the basket with the plant is placed in the ground and any root disturbance is thereby avoided. Professor E. E. Cheesman of the Imperial College of Tropical Agriculture, Trinidad, has kindly supplied a description of the method of constructing these baskets. The very admirable drawings which he also sent make the process entirely clear. From Professor Cheesman's letter :—" The baskets are made of the stems of ' tirite ' (*Ischnosiphon Arouma* Körn.), a marantaceous plant growing abundantly in the local forests. These stems are about 1 cm. in diameter. They are split lengthwise, scraped to remove the pith,

* Garner, R. J., and Hammond, D. H., 1939. Shield budding. Treatment of inserted buds with petroleum jelly. *A.R. East Malling Res. Stat. for 1938*, pp. 115-17.

† Garner, R. J., 1934. The use of rubber strips in budding fruit trees. *A.R. East Malling Res. Stat. for 1933*, p. 263.

‡ Torres, J. P., 1939. Progress report on citrus hybridization. Budding. *Philipp. J. Agric.*, 10 : 99.

Potting Basket Construction

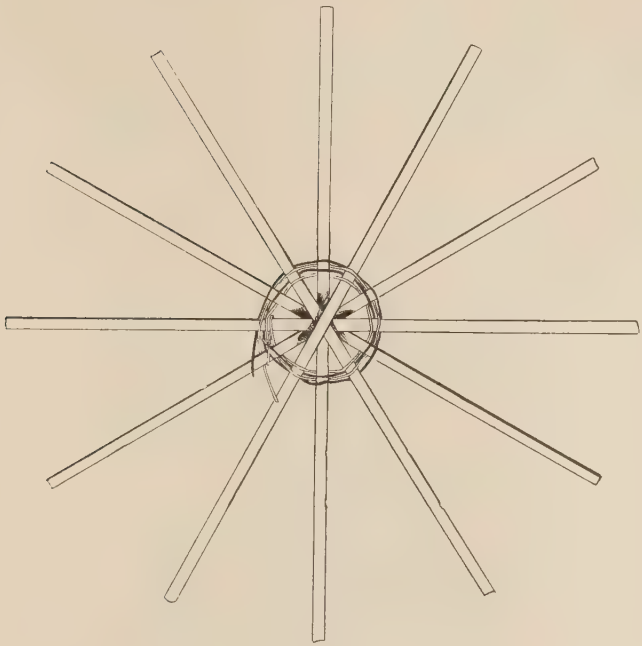


Fig. 1.

Fig. 2.

and dried. The dry material is damped in working to make it easier to handle. The first step in manufacture of a basket is to lay six strong pieces of tirite about 2 ft. long in the form of a star, crossing at their centres. They are fixed in this position by interweaving a circular tie about 5 in. in diameter (Fig. 1). This is the only operation needing any particular skill. The twelve ribs are bent upwards outside the tie, and the rest is a simple, straightforward process of weaving (Fig. 2). The last inch or so of the ' rib ' is bent over and tucked into the weave to finish off the top of the basket (Fig. 3)."

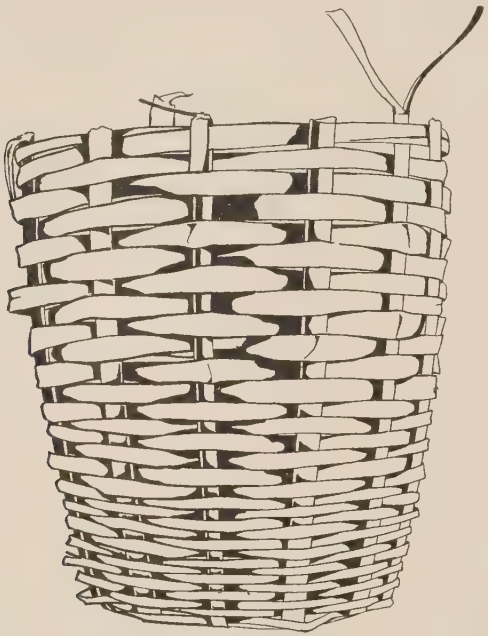


Fig. 3.

PLANT VARIETIES

ACTINIDIA CHINENSIS Planch. (*Dilleniaceae.*) Chinese Gooseberry.

4 A deciduous, dioecious, climbing shrub with edible fruits, which, in New Zealand, are said to sell readily at 6d. to 9d. per lb.

Grafting. 4 Grafted plants bear in their third year, at least two years earlier than seedlings. A proportion of male plants (about 1 male to 6 females) is essential to ensure fruit formation. To secure this with certainty grafted plants are necessary. Some success has been achieved by grafting a strong female scion and a weak male on the same root.

Cuttings. 1, 2, 3 Cuttings 3 to 4 inches long of half-ripened wood in summer or hard wood in autumn will root in sandy soil. The protection of a frame is advisable. Soft wood cuttings are also easily rooted under glass.

Layers. 2 Readily propagated by layers.

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AGAVE SISALANA Perrine, and other varieties. (*Amaryllidaceae.*) Sisal.

1, 4 The plant can be multiplied asexually from bulbils and suckers, the former being used when large quantities are required. According to Miller, suckers cannot be depended on to reproduce an exactly similar plant to the parent, whereas bulbils can. Suckers, he says, make an earlier start than bulbils, but in experiments in 2 progress at the Sisal Experiment Station, Tanganyika, bulbils of *A. sisalana* have made better progress than suckers of the same species. With *A. amaniensis* no difference between the two is observable. It should be noted, however, that the suckers of the first-named came from an estate and unlike the bulbils had no preliminary nursery treatment, whereas both bulbils and suckers of *A. amaniensis* were nursery grown.

Bulbils. 2, 3 Bulbils are produced when the plant, after vegetating for an indefinite period of years (in Yucatan about 15, India 10, East Africa 4-8), makes the supreme reproductive effort which results in its death. The terminal bud, hitherto deeply buried in the leaf bases, begins to grow rapidly, forming a long pole at the extremity of which emerge the lateral branches bearing great quantities (1,000-4,000) of bulbils. These are situated in the axils of the scale leaves just below the flowers, which, except in certain conditions and districts, rapidly abscise without forming seed. These bulbils are removed and planted, preferably in nurseries. Experiments have shown that the procedure sometimes advised of drying the bulbils before planting, with a view to toughening and strengthening the plants, has no appreciable effect.

Suckers. 2, 3 Suckers are produced from underground stems, which may be of some length, and the new plant can be formed at some distance from the parent. If these are

not removed the parent plant will finally be surrounded by a ring of suckers; in fact, in Queensland, as many as 150 per plant have been produced. These suckers are much influenced by the parent plant even to the extent of poling, no matter what their age, when the parent poles. The rate of sucker production appears to be accelerated by a rich soil but the physiological reasons for this supposed acceleration are not yet determined. While some state that suckers removed from a poling parent plant develop vegetatively even if poling in the sucker has started, others advise care in planting suckers from a poling parent since such suckers will themselves pole in a few months and so be wasted.

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ALEURITES spp. (*Euphorbiaceae.*) Tung.

Budding.
4, 5 At the Nelspruit Horticultural Research Station *Aleurites montana* E. H. Wilson is T shield-budded in autumn on rootstocks of the same variety grown from seed sown as soon as ripe the previous year.

The bud is inserted on the stock about 9 inches from the ground and kept in place with a raffia tie.

Bud wood is the mature growth of the current season and buds of a suitable plumpness are obtainable by the time the stocks are ready. They are to be
7, 12 found near the terminals of the shoots. Care should be taken that blind buds are not selected. The shields are cut an inch long. Union is complete in about 3 weeks. If the stock is then cut right back, flush with the bud, the bud will
5 shoot at once. The cut surface of the stock is sealed with wound paint. A desirable parent tree can be made to produce bud wood in quantity by cutting it back the previous season. The nursery is then manured for the first time since planting and, if necessary, irrigated. Transplanting may be done with a ball of soil in summer or with bare roots when dormant in winter.

9, 10 Experiments in Russia with various kinds of budding resulted in ring budding (95 per cent.) proving more successful than either Forkert (90 per cent.), patch (80 per cent.) or T shield (65 per cent.). In these experiments both stock and scion were from year-old untransplanted seedlings.

6 From Java it is reported that *A. montana* is easily budded on nursery stocks a year old, on suckers of cut-back trees and on lateral branches of trees in growth. There appears to be no pronounced polarity, so that bud wood can be taken from leader or lateral. The bud is inserted on a part of the stock where the bud is still green. The modified Forkert method is used and 100 per cent. success is quite usual. The tie is opened in 15-20 days and the top of the stock cut back after a further similar period to about 15 cm. above the union. The budded plants can be transplanted either with dormant or swelling bud, the latter stage being reached two weeks after the removal of the tie.

Grafting.
2 Root whip grafts at the Florida Experiment Station united well but after planting out made poor and unthrifty growth compared with that of budded stocks or seedlings.

Topworking.
1 From Amani it is reported that topworking has been found possible. The method is not stated. In this particular case the object was to replace the large number of male or predominantly male trees by heavy bearing purely female trees. It is possible that sex proportions are not constant during the life of the tree.

Rootstocks.
11 At Florida Agricultural Experiment Station seedling trees of *A. montana* grow vigorously but fruit little. A tree of *A. montana* grafted on *A. Fordii* fruits prolifically.

3 Attempts to use *A. moluccana* Willd., the candlenut, as a stock for the more useful species have not been very successful. A sound union is apparently made but the plants die after planting out, while undisturbed buddings perish after the stock is cut back.

6, 7, 12 *A. Fordii* apparently succeeds well on *A. montana.*

Layers.
10 Layering of 2-year-old branches, either with or without ringing at point of contact with the soil, was 100 per cent. successful with *A. Fordii* and *A. cordata* in Russia.

Marcots.
10 As for layers. The marcotted portion of the branch was enclosed in a bamboo tube filled with sand. The result was much fibrous root.

Cuttings, Stem.
Stem cuttings have so far proved difficult to root.

Cuttings, Root.
8, 10 Success with root cuttings is claimed from Russia for *A. Fordii, A. montana* and *A. cordata.* The cuttings were set in washed rivers and in frames and covered with shaded lights in March and July. The sand temperature was from 62°-77° and that of the air 68°-86°. The cuttings were inserted vertically, the upper end uppermost and covered with about half an inch of soil. Roots and shoots had appeared by the end of the third month. The size of cutting giving the best results was length 4 inches, diameter quarter-inch.

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BOEHMERIA NIVEA Gaud. (*Urticaceae.*) Ramie. China Grass. Rhea.

3 A herbaceous, perennial, fibre plant.
Nicholls distinguishes a variety *tenacissima*, which lacks the downy white undersurface of the leaves characteristic of *nivea*.

Cuttings.
3 Well-ripened stems of current season's growth cut into short lengths containing three eyes or buds, and planted with the centre bud level with the surface. Cloudy or damp weather will induce speedy rooting; in hot, sunny weather temporary shade will be required.
The cuttings are set in their permanent site, the soil of which must have a good tilth.

2 A method of quickly increasing stock from selected seedlings has been evolved in Kenya. The seedlings are transplanted when 3 inches high to nursery beds, planting distance being 2 ft. by 1 ft. After a year's growth the full length canes are laid overlapping to half their length in furrows 5 inches deep and 1 foot apart. The furrows are made with a ridge plough and afterwards filled in by cross-harrowing with the tooth harrow turned on its back.

Rhizomes.
4
1 In Transcaucasia rhizomes cut 2-2½ inches long, bearing 6-8 buds, are planted at the beginning of the growing season. The Japanese in the Philippines plant rhizomes 10-12 inches long in a slanting position with one-third of the length above ground.

Division.
2, 3 Division of the roots by cutting or pulling apart.

Suckers.
1 The Japanese ramie companies in the Philippines plant suckers separated from the parent plants and lined out about 2½ feet apart in rows 2 feet apart.

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CAMELLIA THEA Link, *see* **THEA SINENSIS** L.

CARPOTROCHE BRASILIANA Endl. Sapucainha.

1, 2 The nuts of *Carpotroche brasiliana* have been found in Brazil to contain an oil similar to chaulmoogra oil and to be equally valuable as a specific in cases of leprosy. The cultivation of this native tree is being taken up seriously by the Brazilian Government.

Budding. Shield budding on seedling stocks of the same variety has been so successful that it has not been found necessary to investigate other methods of propagation. Experimental work in Brazil tends to show that any normal bud wood will do.

Rootstocks. So far only seedlings of the same species have been used as stocks. The condition of the bark has some bearing on success. Buds placed on the old ash-coloured bark invariably die while those on the younger chestnut brown bark are usually successful. Buds inserted at the point where the change in colour is in progress also die.
The most successful condition of the stock is at the beginning of a flush when the new leaves appear in the terminal bud but before they actually unfold. The

next best is between flushes when the stock is dormant. Budding at the conclusion of the flush when the new shoots are fully developed and hardening and the leaves have hardened gives only failures.

A bud may remain dormant for some weeks after the tie has been removed (in Brazil the material used is waxed silk). In the early experiments in Brazil a too hasty assumption of failure unnecessarily reduced the percentage of success. The method of cutting back the stock appears to exert no influence on success or failure.

The tree is dioecious. One male to every eight females is considered sufficient to ensure adequate fruit setting. There is a tendency for budded sapucainha to bear too heavily, so much so as to cause defoliation and breaking of branches and exhaustion of the tree.

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CEIBA PENTANDRA Gaertn. (**Eriodendron anfractuosum** DC. **Bombax Ceiba** L.) (*Malvaceae.* [*Bombacaceae.*]) Kapok. Silk Cotton.

Considerable work on the improvement of this tree is in progress in Java.

Budding. 2, 3 Modified Forkert or patch. The former is to be preferred for ease of manipulation, especially with operators of indifferent skill. Given equal conditions the percentage of success to be expected from either method is about the same, i.e. 95 per cent.

The wood at the back of the bud should be taken out before insertion. The tie is removed in three weeks. In the fourth week the stock is cut back to within 4 inches of the bud. At this stage planting out can be done with the bud still dormant, or two weeks later when the bud is beginning to swell, the stumps in these cases being quite short. Usually plants remain a year in the nursery. When neither immediate planting nor so long a delay as a year is desired, the bud can be kept in dormancy for several months by deferring the cutting back of the stock until just before transplanting. An advantage in planting directly after the first cutting back of the stock is that a second check caused by the necessary cutting back or stumping of the now growing budded plant at transplantation is avoided.

1 In Java kapok is either budded (1) in the nursery low down on year-old stocks; (2) on to older stocks, in which case three buds are placed at an equal height round the stem at an optional distance from the ground; (3) on the shoots which grow out after the tree has been headed back.

A new method reported to give very good results is that of budding on uncut lateral branches of older trees. After the buds have taken the branches are cut back to the union, but the central leader shoot of the main stem is often left so that its branches in turn may be budded. These branch buddings should be at a little distance from the trunk so that there may be plenty of room for development.

Grafting. 2, 3 Whip, whip-and-tongue, cleft and almost certainly other methods of grafting are practicable, but judged by experiments in the Philippines they are on the whole less successful and more trouble than budding.

Rootstock. 3 The age of the stock, within reason, appears to be immaterial, budding having been successful on trees up to ten years old, but budding at six months to one year

is normal practice. The bud is usually placed 4-5 inches above the ground, but, so far as success is concerned, height above ground is not significant. After the bud has grown the few inches of stub left at the first cutting back of the stock can be reduced in length by a slanting cut.

2, 5 Rootstock Influence. In the Philippines the wild Surinam kapok, *Ceiba pentandra* var. *caribaea*, when used as a stock, appeared to transmit its known shy-bearing propensity to the ordinary kapok scions grafted on it. These had not fruited seven years later, although nearly 40 feet high, in contrast to the scions on seedling stocks of *C. pentandra* which fruited almost within a year of budding, when 5 feet high. The delayed action effect of this variety is confirmed by work in Java where the study of rootstocks is active. Stocks under trial in Java are varieties known as giant kapok, yellow kapok, Bondowoso, and certain hybrids.

Cuttings. 3, 4 Any kind of cutting will grow, even, it is said, the trunks of felled trees. Cuttings of fairly large dimensions are preferable. Cuttings produce a fruiting tree more rapidly than seeds, but so far as is known trees so raised are shorter-lived, less well-rooted, and more liable to termite attack during the rooting process.

3, 4 In the Philippines cuttings from 18 inches to over 7 feet in length and from $\frac{3}{4}$ to $2\frac{1}{2}$ inches in diameter set deeply in the ground are used with success, the wood being well ripened and at least a year old. When transplanted such plants are cut back to 3 feet and a ball of soil retained.

Plant Material. 1, 3 The axial dimorphism of the kapok limits choice of scion wood. Buds, grafts and cuttings must be taken from the erect, growing branches or suckers to produce an erect tree. Wood taken from laterals will produce drooping or horizontal growth. This latter material may be useful in budding the branches of grown trees.

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CERATONIA SILIQUA L. (*Leguminosae.*) Carob.

Budding. 3 Nursery practice is to shield bud on seedling stock with a stem diameter of $1\frac{1}{2}$ inches. Owing to the slow growth of the tree this means when the stocks are 3-5 years old. The bud puts out a strong straight shoot usually without laterals in the first year. Before growth starts in the second year the shoot is cut back to about 10 inches above the union and two or three lateral branches are allowed to grow out to form the framework of the tree. A frame of four to six branches may be obtained by again cutting back the following year, but the smaller number is preferred. After that no further training is given. With a ball of soil on its roots the young carob

2 may transplant successfully ; it will not transplant with bare roots, and therefore pot-grown stocks are usually employed.

4 In Palestine, however, the Department of Agriculture has found it preferable to plant out the seedling stocks at an early age rather than to grow them in pots. The percentage of takes is much higher and the plants make more rapid growth.

Rootstock. 1 Nursery rootstocks are grown from seed of the common form. Often the domestic varieties are topworked on wild trees. It is said that male and female trees are not compatible.

3 In Cyprus the wild trees grow in bush form owing to constant eating off by goats. Such trees selected for topworking have first of all to be protected and allowed to develop two strong leaders, all other growth being trimmed off. Three years is suggested as a minimum time for selected leaders to be ready for budding, that is 1½-2 inches in diameter at the point where the bud will be inserted, viz. 4-5 feet above ground. Shield or patch budding can be used. Old trees are cut back nearly to the fork and buds placed on three or four of the shortened branches. The usual season is mid-April to mid-June. Dormant budding in September has not proved very successful.

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CINCHONA spp. (*Rubiaceae.*) Quinine.

In Java, where quinine is chiefly grown, grafting is now a routine process. The scion variety is *Cinchona Ledgeriana* Moens and the stock *C. succirubra* Pav. (*see* Rootstock).

Grafting. 1, 3, 4 The methods found most successful are the side graft and bark side graft on year-old seedling stocks. The former is described and illustrated on p. 13. In the bark side graft the stock is prepared by peeling down a tongue of bark sufficiently wide to cover the scion on replacement. The scion is taken from green shoots about half a pencil in thickness and consists of two nodes, the upper part of the scion being cut off about one inch above the upper joint. The base of the scion is prepared by a single long slanting cut from a point opposite the lowest bud, which must now be removed, or it can be cut wedge-shaped, as in the side graft, through the lower joint. The scion is then placed against the exposed surface of the stock so that the cambium of each is in contact and the tongue of bark, which may be in two strips, is returned over the basal end of the scion, tied firmly in position with raffia and thickly waxed. In Java the leaves of the scion are shortened to half their length ; in the Belgian Congo they are removed altogether. As soon as the buds on the scion shoot, the stock is cut back to one foot above the union, and when the scion is a foot long or has made three or four pairs of leaves the stock is cut back to the union and any leaves remaining on the stock are removed. To encourage the bud to shoot, the growing point of the stock is sometimes pinched out or a transverse incision is made in its bark 4 inches above the grafting point. The stock is usually budded when a year old and plants so grafted remain in the nursery 8-10 months longer. Success is about 90 per cent. Grafting on pieces of root, the graft being plunged in genial bottom heat with the point of union underground, gives good results.

Rootstocks and Scions. 1, 2 *C. Ledgeriana* has a considerably higher quinine content than other species but is difficult to cultivate on its own roots except on good virgin land ; replantings on the same land usually fail and regrowths as coppice are unsatisfactory and, in addition, the seed is heterozygous and produces a multiplicity of forms of differing

value. The Dutch in Java have surmounted these difficulties by grafting the more accommodating *C. succirubra* stock with *Ledgeriana* scions from selected clones. Preference is given to the broad-leaved forms of *Ledgeriana* and vigour of growth is essential. (Much information on the technique of quinine production in Java is contained in the report of Sir Frank Stockdale on his recent visit to
3 Malaya, Java, and elsewhere, and readers interested in this crop should study it.)
4 In the Belgian Congo *C. robusta* is also occasionally used as a stock.

In Java the seed for rootstocks is rigorously selected. Each seed is examined for size of germ and quantity of food supply by specially trained women using a glass table over an electric light. Seeds showing a discoloured rootlet in the embryo are discarded. Germination tests are made of all selected seed and a germination of 90 per cent. within nineteen days is required. Seed can be kept in suitable storage for a considerable time.

3, 4 The stocks are raised from seed sown in well-drained nursery beds containing a fair proportion of sand and finely divided organic matter. The beds are covered in with glass and shaded with split bamboo. In the Belgian Congo the beds are enclosed in pent-roofed bamboo shelters with movable front shutters. The shelters are about 3 feet high at the back and 6 feet in front. The rows of shelters are so spaced in depth that the front shutters after removal can still be used to provide a modified shade by resting them on the lowest part of the roof of the row in front and slanting them backwards on to the higher frontal bar of the structure behind. Plans and measurements for constructing these shelters are given by Stoffels. The seed is broadcast at the rate of 2 grammes per m. to obtain 1,500 plants and the beds are watered by means of a spray before and after sowing. The second watering is to fix the seed into the soil. The seed is not covered. The frames or shelters are then closed down and kept darkened until the seeds germinate. Humidity is maintained by mist spraying as required. The seeds germinate in a month or two, and light and air are gradually admitted from the time when the seed begins to burst; by the time the seeds have made several leaves full air and light are admitted except that the overhead shading is still maintained. The germination period is a critical one. The radicle is liable to be attacked by a fungus which destroys the positive geotropism of the plant with the result that the radicle lies on the surface of the soil without entering it. Correct watering during germination plays an important part, since too much favours fungus attack and too little causes the radicle to lose contact with the soil. Nevertheless a moderate drying accomplished through ventilation and not by direct sunlight should alternate with the watering, since such alternations of moderate dryness and moisture discourage the fungus. Sprayings with a copper fungicide from the time when the seeds are swelling also achieves some control. When the first pair of leaves have been formed the plants can be considered fairly safe. When the seedlings are $2\frac{1}{2}$ inches high they are transplanted 6 inches apart to shaded nursery beds where they remain until grafted. In the Belgian Congo the shading of the seedlings when pricked out is done by means of fern fronds set close together in the ground so that they touch overhead and form a thick shade over the young plants. Their slow drying progressively reduces the shade and in three months the nursery beds are fully exposed. If ferns are not available, thatched "lights" are used as a covering and after three months the material from these is gradually thinned out until full exposure is made. Plants suffering from excess of sunlight develop a reddish-brown leaf.

Cuttings.
2 In the sub-tropical parts of Russia, but where winters are still sufficiently severe to prevent the permanent establishment of the tree out of doors, a remarkable system of cultivation has arisen. By this system very large quantities of cuttings are raised under glass throughout the year; planted outside 40,000 to the acre in summer, dug up and taken to the factory in autumn where the whole plant is used in the manufacture of cinchona alkaloids. The cuttings, which may be

taken all the year round if adequate heat is provided, are raised in cold frames and unheated glasshouses from June to August and in the remaining months with bottom heat in frames in hot houses. The supply of cuttings is obtained from store plants planted outside, 8 inches by 8 inches apart, in shaded beds in summer or in glasshouses during the winter. The cutting is taken when the young shoots have made three pairs of leaves. It consists of the two top nodes. The third node is left to produce further shoots which are usually ready a month later. These two remaining dormant buds (the leaves are opposite) may not both make simultaneous or equal growth. Every cutting should be so taken as to leave at least one pair of dormant buds behind it. Too frequent cutting weakens the plant, but a year-old store plant under glass should yield 8-10 cuttings during the winter and an increased number outside. The rooting medium in the propagating houses is sand, maintained, except in full summer, at a temperature of from 71° to 82° F. by means of bottom heat. Temperatures over 82° F. injure the roots. Rooting at 60° F. is possible but much delayed. In cold frames the rooting medium is a substratum of light sandy soil of almost neutral reaction overlaid with 1½ inches of sharp sand previously green manured. The usual cutting is about 1¼ inches long and must contain at least two internodes, of which the top one especially from the secondary growth is often extremely short. The cut, however, can be made *above* the second joint without lessening the probability of root formation. Thin cuttings are preferred ; the shoots which develop on the upper non-woody part of the stem and are usually characterized by closely crowded internodes are too thick and take several months instead of the usual 17-25 days to root. Spacing in the cutting beds is usually 2 inches by 2 inches. The leaves are not shortened. In cold frame rooting the cuttings remain in the frames during the summer and are then removed to heated houses or the frames themselves are heated and the cuttings left. Experiments in so hardening the cuttings that they may be overwintered in unheated frames are in progress. Rooted cuttings in these small-scale experiments have survived temperatures of 20° F. Factors employed with success in producing increased winter hardiness are a short day of 8 hours light, no shading and a minimum of watering, while during the winter all the light possible must be admitted. The attentions the cuttings receive during growth do not differ from those normally given to most plants raised under such conditions. In 25 days after setting, by which time the cutting should have rooted in the hotbed and have at least 5-10 roots half an inch long, it is transplanted, still under glass, to a bed of light soil and grown on until 3 inches high when it is transplanted into boxes holding forty or more for gradual hardening and eventual removal to the summer beds outside. The upper layers of sand in the cutting beds are changed frequently and all the sand in the beds is entirely renewed every six weeks.

The output of material for cuttings from any given parent plant can be increased by cutting it back to 4 inches above ground level and fastening down the resultant shoots by their tops by means of pegs and string so that they form an arc. As a result of the tension set up dormant buds will start into growth all along the shoot. These are taken off for cuttings when they have made three joints, care being taken to leave the lowest joint of each cutting on the shoot as a starting point for fresh growth. A three-year-old bush so treated will produce 60-80 cuttings as against its usual 7-10. Young bushes produce proportionately fewer but the increase is still substantial.

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CINNAMOMUM CAMPHORA Nees. (*Lauraceae.*) Camphor.

1 The Russians have selected and partially fixed a bushy form of the camphor tree. They claim that it is hardier than citrus. The yield is about 170 lb. per acre for two cuttings. It is difficult to propagate vegetatively and therefore it is usual to grow it from seed. Trouble is caused by a camphor-free strain which is much intermixed with the camphor yielding variety and unfortunately hybrids between the two physiological strains are camphor-free, although in interspecific hybrids the camphor bearing and morphologic characters of the camphor yielding strain appear to be dominant.

Budding and Grafting. 1, 2 Both are reported to have succeeded under glass and outside in Russia and Italy. The grafting method was whip-and-tongue. Percentages are not available. Approach grafting was successful in Italy but cannot be used on a commercial scale.

Rootstocks. 1, 2 The stocks which have proved successful are *Cinnamomum glanduliferum* (false camphor) Meissn. and the camphor-free strain of *C. Camphora* Nees.

Layers. 1, 2 Twigs and suitably placed young branches may be layered in spring and autumn and root freely. A slanting cut penetrating nearly to the centre of the twig is made at the point of junction with the ground and is kept open by a small stone or piece of wood, or, instead of the cut, wire ringing may be substituted. All cut or ringed parts are earthed over. Rooted spring layers are cut off from the parent tree in autumn but are not disturbed for transplanting until the following spring. Sucker growth often appears at the collar of trees bent over for layering. This growth can in turn be layered in autumn in whatever space is available round the tree.

Cuttings. 1 In Russia summer cuttings in hotbeds failed. Green and semi-green wood cuttings under glass in spring succeeded usually to about 10 per cent. but on two occasions up to 80 per cent. Etiolation of the lower part of the cutting raised the percentage to 15 per cent.

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* I.N.E.A.C., 14 Rue aux Laines, Brussels.

CINNAMOMUM ZEYLANICUM Nees. (*Lauraceae.*) Cinnamon.

Cuttings. 1, 2 — The tips of young shoots bearing not more than three leaves are taken, preferably from old trees. These are inserted in shaded nursery beds and kept well watered. The method is a quicker one than growing from seed.

Layering. 1, 2 — Side branches pegged down root easily.

Stumps. 2 — Old stumps when transplanted yield shoots of peelable size within twelve months. Before removal they are cut down to within 6 inches of the ground. Root injury during removal is said seriously to reduce success. These stumps are carefully lifted, replanted about 1 foot apart and temporarily shaded.

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CITRULLUS VULGARIS Schrad. (*Cucurbitaceae.*) Watermelon.

The appearance in these pages of the watermelon may be a little unexpected, since it is essentially a crop that is grown from seed. The Japanese, however, claim to have secured for it complete immunity from the destructive fusarium wilt (*Fusarium niveum* E. F. Smith) by grafting it on various immune cucurbits, of which the most successful is one known as the white-flowered gourd. Hitherto the disease rendered it impossible to cultivate watermelons on the same ground for two years in succession. The introduction of grafting enables the same ground to be used for at least six years.

Cleft Grafting. — The point of a young seedling white gourd established in a pot is removed down to the cotyledons. Between these is made a downward incision to the depth of 1 centimetre. In the cleft so made is inserted the seedling watermelon which has been detached from its roots below the hypocotyl, the latter being cut wedge-shaped to fit the cleft. The tie is made with woollen thread and the graft placed in the dark for two or three days. An 80 per cent. take is usual. It is claimed that watermelons so grafted are easier to cultivate and grow faster than on their own roots.

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COFFEA spp. (*Rubiaceae.*) Coffee.

9, 12, 14 — The literature dealing with the vegetative propagation of coffee is fairly extensive. The earliest work was done in Java and contemporary agricultural publications of the Dutch East Indies (from 1887) contain many references to it. The interesting history of these early attempts has been well summarized by Ferwerda (1934) and by Cramer (1934).

At the present time research directed by the various Departments of Agriculture is actively proceeding in many countries of the Empire, notably in Tanganyika where a coffee research station has recently been established, and in Kenya. It should be noted that whereas the Dutch and French concentrate mainly on *robusta,* in Kenya, Tanganyika and Mysore *arabica* is the principal variety grown. Apart from the question of quality an important distinction between the two is that *arabica* is self-fertile while *robusta* is not.

As will be seen, few methods of vegetative propagation can have remained untried.

Budding.

53, 54, 55 Budding has not been regarded with much favour in Java, probably in view of the success obtained with grafting. In the Philippines, however, Wester, that high priest of shield-budding, advised the use of buds from well-matured wood, greyish-brown in colour, from which the leaves had been removed two weeks in advance, i.e., unpetioled budwood. The buds should be cut 1½ inches long. The age of the stock should not exceed 2 years or the bark will be too brittle. Wester says the point of insertion on the stock is immaterial; this is contrary

45 to experience in Tanganyika, where the height of the point of insertion preferred is 9 inches to a foot above ground level, experience having shown that buds above or below this point are unsatisfactory.

At the Coffee Research Station, Tanganyika, shield-budding by the T and inverted T methods brings from 50 to 90 per cent. success according to the suitability

34, 45 of the material. The bud should be just showing green, i.e. on the point of breaking. In making the bud as much wood as possible should be removed from the bark and every precaution should be taken against drying out before and after insertion. Dormant eyes often do not shoot for a long time, instances of dormancy lasting over a year being on record. (*See also* Scion Wood, p. 42.) Normally the bud should start in three or four months after insertion, and fruit about 2½ years later. Apparently any time of year is suitable for budding (not for grafting) in Tanganyika.

16 Galang in the Philippines says that the bud will start into growth more quickly, if the stock is partially cut through above the bud and bent down, the operation to take place when the stock has made some growth after budding. Watershoots which may arise should be removed. The stock is topped when the bud breaks and cut back to the point of union when the bud has grown to 6 inches or 1 foot in length. The time of budding seems to be immaterial, provided the stock is kept moist at the roots. If there is a choice, the period before the rains antecedent to an increased natural sap rise is suggested.

It is often said that bud unions in coffee are apt to break off under stress such as a strong wind and are on this account alone less satisfactory than grafts.

45 In the Annual Report for 1936 of the Coffee Research Station in Tanganyika, however, it is definitely stated that all bud unions have been satisfactory and are unnoticeable at the end of 2½-3 years. Wind damage has not been observed.

34 The buds, unlike the grafts, may, according to Marshall, be taken from lateral branches and still produce upright growth provided they are inserted into an

19, 21, 45 upright leader shoot. This has not been the case at the Coffee Research Station, Tanganyika, where buds from laterals have consistently given lateral growth with upright or leader stocks.

Grafting.

45 At the Coffee Research Station, Tanganyika, up to 90 per cent. success has been obtained under nursery conditions with grafting by the cleft, saddle, side, notch and rind methods on seedling stock 1 to 2 years old.

8 *Cleft Graft.* This method was first used extensively by Butin-Schaap in Java in 1901. A comprehensive study of this method and of the anatomy and physiology

56 of the graft unions thus formed was published by Zimmermann the same year. Butin-Schaap used rather green wood both in scion and stock. The scion carried two pairs of leaves and a terminal bud, the leaves being shortened back to about a quarter of their original size. The stock was only cut back sufficiently to obtain workable wood and retained its lower leaves. The graft was tied, but not waxed, and was covered with a glass tube. [Zimmermann's illustration is reproduced

9 by Chevalier, 1929, *Les caféiers du globe*, on p. 168.] The method was used by its originator to graft the Maragogype, which is of the *arabica* group, and Java coffee on to the nematode-resistant *liberica* stocks. Later, modifications were made.

14 Instead of the green extremity it was found that the best scion wood is obtained from the middle sections of watershoots which are just becoming woody and are of

19 approximately pencil thickness. This has been confirmed at the present day in Tanganyika. The stock was cut off at 8 inches above soil level. The tying and covering were unchanged except that waxed paper cylinders were sometimes substituted for the glass tubes and proved more effective and convenient.

43 In the Philippines successful cleft grafts were made on a variety of year-old stocks (*see* Rootstocks, p. 38) monthly throughout the year, the stocks being sometimes larger and sometimes of equal diameter to the scions. The scion length was from 3 to 5 inches and the stock was cut back to 1 foot from the ground. The tie was waxed cotton tape prepared in advance.

Experiments were made with graft covers (*see* Graft Covers, p. 43).

Whereas in the Philippines a high percentage of success (59-90 per cent.) in cleft
10 grafting was obtained all the year round, in Mysore the most successful period is during the south-west monsoon from March to July (90 per cent.), other times of the year proving less propitious (20 per cent.).

23 In Java, cleft grafting is the only method used in commercial plantations, the best time there for the operation being when the tree begins active growth after rest, but before the sap run becomes too free.

37 In a recent paper a planter in Java asserted that he was able to raise his success percentage from 20 per cent. to 90 per cent. or more by allowing the lower leaves to remain on the stock after cleft grafting instead of cleaning them off as had hitherto been the custom.

22 The technique and conditions found most suitable at the Scott Agricultural Laboratories, Kenya, are as follows :—

29 " *Grafting onto seedling rootstocks in the nursery.* The stocks are planted in rows 2 feet apart and are spaced 1 foot apart in the rows ; the grafting nursery has 50 per cent. shade at a height of 6 feet. Grafting is carried out where the stocks have attained a diameter of 1 to 1·5 cm. at about 15 cm. from ground level. The cleft graft has been found to give the best results, and is the only type used in practice. The scion consists of one node and an internode and may be of hard green, green and brown, or completely brown wood ; so long as the wood is not soft and unripe it may be in any stage of maturity without affecting the success of the graft. It is essential to use vertical shoots for any form of vegetative propagation as horizontal and semi-horizontal shoots produce a flattened tree incapable of making vertical growth. The grafts are tied with gunny twine and waxed with grafting wax or a low melting point paraffin wax, though in the wetter districts of Kenya it has been found unnecessary to use wax. The scion and the union are completely enclosed in a cylindrical waxed paper cover immediately after grafting, to prevent drying out. After two months the cover is removed, and after a further month the tie is cut off. A take of 80-90 per cent. is not uncommon at the best seasons of the year, i.e. when conditions are warm and moist ; it is not possible even with the more or less controlled conditions in the nursery to graft successfully all the year round."

19, 45 In Tanganyika cleft grafting on to 1- or 2-year-old seedlings has given 90 per cent. of takes, with only raffia as the tying material, no wax or tape being used. Raffia used alone has there always given better results than other tying material. Protection until growth starts is given with a cylindrical cover of banana stalk.

Bench Grafting. In Tanganyika bench grafting of soft wood scions on hard wood
48 stocks is being tried, the whole being inserted as a cutting in propagating frames.

43 *Rind* or *Bark Graft.* Successful work was done recently in the Philippines with this method, using 3-year-old stocks of several varieties headed back to 16 inches, and several different covering materials (*see* Graft Covers, p. 43). The scions, also drawn from a number of varieties, were from 3 to 5 inches long with leaves shortened back almost to the petioles and always carried at least two internodes. The oblique cut at the base of the scion was made

about 1¾ inches long but the scion was not pushed down to the full extent of this. In Tanganyika, rind grafting gives about 90 per cent. take, the plants, however, are mainly weak and it is not considered a good method.

Chevalier (1929) says that this graft is usually impractical, especially with trees over 2 years, because of the brittleness of the bark.

Whip Graft. Whip grafting was the first method to be used in Java (1887). It was recommended that the scion should be about 4 inches long and have two pairs of leaves shortened to a half or three-quarters of their length. The rootstocks were grown in pots. After grafting the plants were kept in glass-covered pits or under a closed glass frame for a few days, after which air was gradually admitted. The glass was wiped free of moisture daily.

The grafts were tied but not waxed. Subsequent experience has shown that glass-covered frames are not necessary, provided that the graft is protected from drying out by some covering and is kept in the shade (*see* Graft Covers, p. 43).

Side Graft. Side grafting on to seedling stocks has given good results (90 per cent. success in Tanganyika). A form of side graft on very young seedlings (also an approach graft, *see* Inarching *below*) was used by Thierry in Martinique when in 1898 he sought to use the nematode-resistant *liberica* as a stock for the susceptible Martinique variety of *arabica*. A cut an inch long was made downwards from the axil of the cotyledon of a small seedling *liberica*. In this slit was inserted and tied an *arabica* scion, bearing a pair of laterals and a terminal bud, its lower end cut to a two-sided wedge.

These grafts were kept close in a humid atmosphere under glass for the first week, after which air was gradually admitted.

Herbaceous Graft (so called), or the *Borel Graft.* This method was tried experimentally at Bingerville Experiment Station on the Ivory Coast in 1934.

The scion is a green shoot with a terminal bud and two pairs of lateral buds, the attendant leaves being removed. This was cleft grafted on to a green shoot from which only the tip had been cut off. The graft was tied with raffia but not waxed. Success was 12 per cent. in April. In later experiments, May-June and July-August, a modification was made, the stock being cut off 3 inches from the top and the scion, though still containing at least two nodes, was deprived of the terminal bud and the first node, thus providing a less sappy wood. This modification gave 40 per cent. and 78 per cent. success; possibly, however, the greater success was due to seasonal conditions, for when this type of scion was used in April it achieved a take of only 6 per cent. against 12 per cent. unmodified, whereas in the short dry season in July to August, all other varieties of graft which had been used in these experiments and had failed previously, also did well.

Inarching. Thierry's method of inarching or approach grafting was carried out on young seedling plants of *liberica* and *arabica* in 1898, the object, as already stated (*see* Side Graft *above*), being to provide a nematode-resistant stock for the Martinique *arabica*.

Stock and scion plants, having each made one pair of leaves in addition to the cotyledon, were lifted with bare roots. Starting just above the cotyledon on stock and scion a downward cut towards the roots was made removing a cotyledon and then a strip of bark 1-1½ inches in length. The two cut sides were brought together and tied, both sets of roots being left intact. The graft was potted in a bamboo pot previously prepared, stood in an airy and shaded place and kept watered. In 15-20 days the plants had taken hold and union had also been effected. Five weeks later the *liberica* top was pinched out but both sets of roots were left until planting out in 8 to 10 months' time when the *arabica* roots were removed.

J. Dybowski, working under glass at L'Institut coloniale de Nogent-sur-Marne, simplified the operation with success by leaving the cotyledons in place and making

the union below them. The case for leaving both sets of roots permanently on the plant was considered, but it was thought that the probable eventual decline of the *arabica* roots through nematode attack would result in weakening the plant, which by that time would be making full use of both sets.

17 The method is used in Java at the present time but the plants are joined at a much younger stage, i.e. when possessing only cotyledons. These are left in place and the union made below them.

1, 2, 19, 22, 27 In Kenya and elsewhere year-old plants have been inarched onto stumped trees. An account of the method used at the Scott Agricultural Laboratories, Kenya, is of interest : " Inarching has been used as a means of topworking coffee in the western coffee growing districts of Kenya, where the rainfall is heavier than in the eastern districts. Blue Mountain coffee has proved fairly resistant to coffee berry disease (*Colletotrichum coffeanum*) and inarching has proved of value in converting existing plantations of susceptible coffee to this variety. The ideal seedling for inarching onto a mature coffee tree should be at least 18 inches high with a healthy root system. A smooth section of stem is selected against which the seedling is laid. There is no need to plant the seedling, it being sufficient to scrape earth from the centre of the row onto the plant, and to pack this firmly so that the plant lies against the stem of the rootstock at the point where inarching is to be carried out. When the seedling has a hold in the soil, indicated by vegetative growth, the rootstock is stumped at 2 feet from ground level and inarched as follows. After rubbing away all loose bark, lichen, etc., from the rootstock a vertical slit is made 3 inches long, with horizontal slits 2 inches long at its extremities ; the cuts thus form the letter H on its side. The flaps of bark are carefully lifted from the wood. A section of the seedling stem corresponding to the horizontal incision in the stock is sliced off to form a flat surface and this is inserted under the flaps of bark, bringing the cut surface into full contact with the cambium of the stock. The union is held firmly by binding with strips of waxed calico. The roots of the seedling are not removed after the inarch has taken but are allowed to die off naturally. A take of 80 per cent. is considered reasonable using this method of inarching."

1, 2 In Tanganyika (Amani) inarching *C. arabica* onto *C. robusta* stocks has given a very good percentage of takes and the plants seem to stand field conditions fairly well.

Root Grafting. 5, 17 Certain experiments were carried out in Java recently. The portions of root used were pieces 4-8 inches long of taproots and laterals taken from 6-year-old trees of *robusta* types dug up for the purpose. The diameter of the root pieces is described as " of normal graft thickness ". 320 cleft grafts were made, 19 being on taproots ; the scions were other *robusta* types. They were planted in covered frames. Eventually all failed. On examination it was found that owing to the extreme hardness of the wood it had split beyond the cut made to receive the scion, resulting in an uneven surface and lack of proper contact. A second batch consisting of 226 perfectly fitting whip grafts was then made ; some were waxed and others not and some were in covered and some in uncovered frames. In ten days all in the uncovered frames and half of the unwaxed grafts had died and in two months all had died, although a number had begun to form unions. A third attempt was made, using roots 6 inches long from the same trees as before and of the same thickness as the scions which, this time, were young seedlings not long germinated, bearing cotyledons and one pair of leaves. Five groups of grafts were made :—

1. The complete seedling scion-grafted at the hypocotyl by cleft graft.
2. The complete seedling scion-grafted at the hypocotyl by side graft.
3. The hypocotyl bearing cotyledons but having the stem above the cotyledons removed.
4. The portion of stem removed from 3.

5. The hypocotyl+a piece of its taproot grafted on a lateral root piece to ascertain whether a root-on-root graft obtained a better union.

The grafts were inserted in light soil in frames, the union being above ground to prevent scion rooting. Part of the grafts were covered with glass tubes and part with paper cylinders. These grafts united well, 100 per cent. under glass, but less successfully under paper.

Examination four months later showed that all had made good root growth with the exception of No. 4, which was almost certainly retarded by the absence of the cotyledons. All grafts had formed a taproot (the root pieces used were laterals). After a further six months all plants had normal root development for their age. Group No. 4 had now rooted but was still lagging behind both in root and top growth. Later these plants were to be top grafted with scions from the clones which had failed in the previous root grafting experiments. The value of the method is that a large number of grafted trees can be obtained of identical make-up except that the intermediate will be of seedling though clonal origin.

Rootstocks. Though coffee is strongly susceptible to rootstock influence, until recently little direct experimental work on rootstock selection had been done and such information as is available has largely been gathered in the course of other research.

12 *Java.* The grafting of *arabica* on *liberica* is a difficult operation and the percentage of success is low. Butin-Schaap's first grafts of *C. arabica* var. Maragogype
14 in 1901 had no lasting success (*see* Grafting, p. 34). Among *robusta* stocks there are clones with a wide range of compatibility the seedlings of which, producing strong growing plants, come early into bearing irrespective of the scion variety;
52 such a one is Bgn 124-01 which is a satisfactory stock for a number of *robusta* varieties and for *liberica-arabica* and *Uganda-congensis* hybrids. Seedlings of Quillou Bgn 121 also produce stocks suitable for most *robusta* clones. Unsatisfactory stocks also exist, e.g. Bgn 59 on which three different clones took badly, yielded 30-50 per cent. of failures when planted out and were always backward in development. Successful grafted trees came into bearing earlier than seedlings, for instance a two-year-old grafted plantation will have as many as 80 per cent. of the trees in bearing compared to the 15 per cent. of seedlings of similar age.

12 At one time great hopes were entertained of *excelsa* which is drought-resistant
23 and grew well on most soils up to 4,000 ft. However it has proved incompatible with many *robusta* scion varieties. Kawasari D., however, an *arabica-liberica* hybrid, does well on *excelsa*.

Seedlings derived from *robusta* × *Quillou* have proved excellent stocks (though of course in variable degree) for *liberica* and *liberica-arabica* hybrids, which do better on it than on the more closely allied *excelsa*.

33 Recent trials with *arabica* seedlings as the stock and with an unknown variety of *robusta* as scion produced at first beans having a peculiarly oblong appearance and a taste superior to that of the coffee from the unworked scion parents. When, however, the locality was changed these differences disappeared. A further series of grafts, which have not yet fruited (1937) with *arabica* seedling stocks and *robusta* and *Conuga* scions have shown a markedly larger development of both root system and scion when compared with ungrafted seedling *arabica* of equal age or even six years older.

3 *Tanganyika.* In the 8th annual report (1936) of the Amani Research Station it is recorded of the inarching of *arabica* on *liberica* or *robusta* that vigorous stands of young plants were established which, however, suffered in some instances, from severe die-back when cropping, due, it is tentatively suggested, to carbohydrate depletion.

25 It is also suggested (from Kenya) that owing to the *robusta* rootstock having a much shallower root system than *arabica* the *arabica* grafted on it may be more susceptible to drought.

4 In the 9th annual report of Amani (1937) the combined yield per plant for 1934-6 for *arabica* scions inarched in 1931-2 in the seedling stage onto *robusta* seedling stocks is shown to give a mean yield of 3,663 grammes of cherry per plant with a coefficient of variability of 59·2 per cent. In 1936 the yield was much reduced but with the promise of a heavy crop for 1937. Five *arabica* grafted on yearling stocks of *liberica* early in 1932 have given a mean yield of 11,800 grammes of cherry per tree over the same period with a coefficient of variability of 29·7 per
34 cent. Stocks other than *liberica* and *robusta* on which *arabica* has been a successful graft are *C. bukobensis* and *C. Quillou*.

24, 29 *Kenya*. The rootstock experiment at the Scott Agricultural Laboratories which consists entirely of single stem trees reveals no difference so far between *C. arabica* seedlings and *C. arabica* scions grafted onto a number of varieties of *C. arabica*. When, however, *arabica* is grafted onto certain other species of coffee a marked reaction is apparent; e.g. *C. arabica* on *C. eugenioides* produces a very much dwarfed and sickly tree; *C. arabica* on *C. robusta* produces a tree susceptible to drought. In the case of multiple stem trees there appears to be a tendency for grafts to produce more secondary growth on the primary branches than is usual
31 with seedlings. None of the many indigenous and imported plants of the order *Rubiaceae* has been found to be compatible.

43 *Philippines*. In certain grafting experiments in which 3-year-old *excelsa* and *Quillou* were the stocks, the scions *robusta*, *excelsa*, *Quillou* and *liberica*, and the methods cleft and bark grafting, a slightly higher percentage of take was obtained on *excelsa* by both methods. Of the two, cleft grafting (76·6 per cent.) was slightly superior to bark grafting (74·8 per cent.). Stock effect had not had time
41 to develop when the paper was written.*

10 *Mysore*. At the Coffee Experiment Station promising results are being obtained with the vegetative propagation of rootstocks following the etiolation methods used at East Malling with apple.

The most suitable age at which to graft seedling rootstocks is considered in general to be one year old from time of sowing.

13 The possibility of the stock influence being carried on into the seed progeny of the grafted plant, even though the apparent influence of the stock upon the scion is small, is occasionally mentioned. In support of this possibility Daniel's experiments may be quoted in which the seedlings raised from kohl-rabi grafted onto brussels sprouts differed widely from those of the controls, particularly in the great reduction of the swollen root. Differences also appeared in the seedlings of grafted peas and beans. In these the effect of grafting was to dwarf them, and the dwarfing reappeared in their seed progeny.

Topworking. In Java on seedling plantations it has been found that 75 per cent. of the yield is
14 produced by 47 per cent. of the trees and presumably something of the sort holds
20 good in other countries also. (These results have now been confirmed in Tanganyika on 20,000 trees.) A successful method of top grafting the low yielders with scions from known productive trees is, therefore, very desirable. Certain methods are in common use but it cannot be claimed that any of them are uniformly successful and the conditions which lead to success or failure are probably not yet fully understood.

11, 22, 35 *Grafting on Suckers or Watershoots*. In Java and Tanganyika, suckers raised low down on poor-yielding trees are cut back and cleft grafted when they reach a suitable degree of firmness. The rest of the tree above the grafts is cut back later after serving its purpose in providing shade for the graft. This shade must not be left long after the graft has begun its characteristically rapid growth or the result will be a feeble and attenuated shoot.

* Further information on Kenya rootstocks will be found below under Topworking.

14 Grafts on suckers of old cut back trees come into bearing a year earlier than the grafts on nursery stocks. In Java it is usual to work four watershoots per tree, the best only being finally retained.

6 In the Philippines it was found that after heading back a tree watershoots emerged in from 3 to 4 weeks and were ready for cleft grafting in from 115 to 381 days according to vigour, the average being 250 days. Young scions worked on these Philippine trees were less successful, through drying out, than scions of more mature wood.

23 A form of topworking sometimes used in Java on *robusta* is that in which the sucker is encouraged from the top of the main stem and grafted with a scion from a lateral rather than from a vertical branch, thus ensuring a lateral spread at a convenient height.

Topworking Direct onto Stumps either by rind or cleft grafting presents difficulties which are avoided by working onto suckers and is seldom practised, but at

34 Morogoro, Tanganyika, cut back branches of 6-year-old *excelsa* trees were successfully (92 per cent.) rind- and side-grafted. The grafts were bound with tape and wax and as little time as possible was lost between preparing stock and scion and the covering of cut surfaces. Speed in this connexion is regarded as an essential factor for success in coffee grafts. Cuts should be made at or just above a node ; with internodal cuts the branch will die back to the node and the graft will fail.

29 Information of much practical value has been received from the Scott Agricultural Laboratories, Kenya. Originally put out as a broadcast talk, it is quoted here with a few slight adaptations and the omission of passages dealing with quite elementary principles :—

" Coffee in Kenya has originated mostly from seed which produces a multiplicity of types. Many of them can be distinguished by eye alone, but light or heavy cropping types can only be isolated with any certainty by individual tree recording over a period of at least three years. When it has been proved that certain trees in a plantation consistently bear heavy or even medium crops, it is hoped that it will be possible to take scions from these trees, and graft them onto the remainder of the plantation ; this is known as topworking. In Java, with *robusta* coffee, topworking of all uneconomic trees in a plantation with scion wood taken from known high-bearing trees, resulted in 33 per cent. increase in crop, over the whole plantation. There is no reason to suppose that similar results will not be obtained in Kenya. In 1937 an experiment was laid down to investigate the technique of topworking coffee, to determine to what extent climatic conditions influence the success of grafting, and to find out whether it could be carried out as an estate practice. The experiment was carried out on thirteen blocks of coffee, all over ten years old, and situated on thirteen estates, so placed as to give the maximum variation in rainfall, temperature, soil conditions, etc.

The range of the experiment was from upper Kiambu, altitude range 4,900 feet to 6,200 feet, through lower Kiambu, Ruiru, upper Thika, lower Thika, Makuyu, Mitubiri and Donyo Sabouk. The original plan was to graft two rows of six trees each, on all estates, every four weeks, over a period of twelve months. One row to be stumped, and the scions grafted direct onto the stumps. The other row to have scions grafted onto suckers, produced by previously ' cutting up ' the trees, in the manner for converting from single to multiple stem. Grafting commenced in May 1937, and in July the stump grafting method was abandoned, as only a few ' takes ' were registered, and it was only possible to graft trees which had smooth stems. Sucker grafting is carried out as follows :—The trees to be grafted have all their primaries removed, except for a few at the top, which are left as a shade canopy. The resulting suckers are large enough for grafting at approximately six months from the time the trees were cut up. Three suckers, arising about nine inches from ground level, are grafted on each tree. The method used

is the cleft or wedge graft. All the grafting in this experiment was carried out by natives. It takes one native grafter and his assistant about ten minutes to graft one tree.

All grafts are tied with gunny twine, waxed, and covered with waxed paper tubes, to prevent drying out. A small bundle of grass tied round the main stem of each tree, and hanging down over the grafts, provides shade. The paper tubes remain over the grafts for eight weeks, after which they are removed and the graft examined. Grafts which are still alive when the covers are removed, have not necessarily formed a union with the stock, and the binding which holds the scion in place is not removed until another four weeks have elapsed. By this time the scion may have made as much as twelve inches of growth, and if good growing conditions prevail, a further twelve inches will be made during the next two months. The rate of growth varies considerably from district to district, and from month to month in the same district. Growth is much more rapid in the warmer districts, as would be expected.

The success or failure of grafting is dependent on many factors, climatic, personal, physiological. Let us take climatic factors first. The great problem in grafting coffee was, and still is, to a certain extent, the correct time of year to graft. The difference between 100 per cent. take and complete failure may be brought about by only two months difference in the time of grafting. If a batch of grafts fail, it can sometimes be attributed to one or more factors, such as excessive rain or heat. If good results are obtained it is clear that the optimum combination of climatic conditions prevailed at the time of grafting. In 1937 the best results were obtained by grafting in November, when the average take was 66 per cent. for twelve estates, the highest result being 94 per cent. and the lowest 38 per cent. These figures are based on the number of grafts (three on a tree). If the percentage is based on the number of trees successfully grafted, the figure works out at 94 per cent. The climatic conditions prevailing in November are known, but everyone knows that the Kenya climate is far from reliable, and there is no guarantee that the same conditions will prevail in November 1938.

The grafting carried out at the end of May and beginning of June 1937, resulted in a take of 30 per cent. for the six estates in the Kiambu district, and 63 per cent. for the six estates in the warmer districts. These results point to the fact that warm, moist conditions are favourable to grafting, and cold, moist conditions unfavourable.

Grafting carried out in December, January and February gave very poor results indeed, except in one or two cases at the higher altitudes, and it is therefore assumed that dry, hot conditions are unfavourable for grafting.

It appears, then, that if grafting is carried out when warm, moist weather conditions prevail, success will result. If, on the other hand, grafting is done under cold, wet conditions, or hot, dry conditions, the operation will fail. . . .

[Importance of personal factors is stressed. Native grafters should be carefully selected, well paid and fed.] . . .

It might be as well to mention here that grafting should not be carried out in the hot sun ; it has a bad effect on the grafts, by drying them out, and on the grafter, by making him sluggish at his work. Grafting is best carried out in the early morning or late afternoon, when conditions are cool.

Something must now be said about the physiological factors affecting grafting. First of all it must be admitted that very little is known about this side of the question and that what is about to be said is largely theorizing. The general health of a coffee tree, and particularly its carbohydrate status, seems bound to influence the result of grafting. If a tree is suffering from die-back after bearing an over-heavy crop, it is unlikely that grafting would be successful. The condition of the scion wood used will also probably affect the result. It is hoped to elucidate these points, and to confirm tentative conclusions already reached, in another

experiment which is about to commence. It was thought that there would have been an optimum stage of ripeness of the scion wood and of the suckers grafted on to. This has been found, within certain limits, not to be the case. It is possible to use scion wood in any stage of ripeness, ranging from hard, green wood to mature greyish wood, with equally good results. Very soft, green wood should not be used, either for scions or stocks, as it falls an easy prey to fungus attack.

Very little is known, as yet, about the degree of compatibility between the different varieties of *arabica* coffee and the ordinary Kenya or French Mission stock. Preliminary observations point to the fact that all of the varieties are compatible with this stock.

The question of rootstocks, which was mentioned in a general way earlier in this talk, is being investigated at the Scott Agricultural Laboratories. An experiment was laid down a few years ago, consisting of blocks of different rootstocks, grafted with scions of one variety of *arabica*. The rootstocks are varieties of *arabica*, such as ' Blue Mountain ' and ' Kent's ' ; selections within *arabica*, such as the red-leaf form, occasionally seen in coffee plantations ; and species other than *arabica*, such as wild Nandi coffee, *C. robusta* and *C. excelsa*.

So far no difference is observable between the plots grafted on varieties and forms of *arabica*. This confirms results obtained in Java with *robusta* coffee, where it was found that the influence of the scion was greater than that of the stock.

The plot on wild Nandi coffee, however, which is an entirely different species to *arabica*, has had an extremely dwarfing effect on the scions, and it may prove later on to be incompatible with *arabica*. The plot on *robusta* rootstock has proved to be susceptible to drought, which is thought to be due to the shallow root system of that species. This might prove to be of value in districts where a high rainfall tends to inhibit flowering.

The operation of topworking coffee has proved to be little more arduous and expensive than converting a plantation from single to multiple stem. The trees may be expected to produce a small flowering at eighteen months from the time of grafting. In fact, coffee grafting has ceased to be a possibility, and may now be considered to be an economic proposition."

Scion Influence.
23, 32

That the scion influences the stock to some extent is not in doubt and Hille Ris Lambers asserts that its effect is more potent than that of the stock upon the scion.

38

Ottolander in 1899 describes experiments with *liberica* rootstocks by which Java coffee scions reduced the vigour of the root system and changed the colour of the roots. At the same time it was shown that a *liberica* stock receiving an upright leader shoot produced a deeply penetrating taproot formation whereas the root system of those grafted with laterals developed abundance of lateral roots and only a short taproot.

23

In Java in mixed seedling plantations the weaker trees have been converted into vigorous growers by topworking them with a strong-growing scion variety.

33

Robusta and *conuga* scions grafted onto seedling *arabica* produced a root development in the stock equal to that of six-year-old seedling *arabica*.

ScionWood.
12, 14, 18, 28, 32

Coffee possesses a very marked polarity. As a result of this, scions from the horizontal lateral branches will maintain a lateral growth habit and develop into flattened shrubs with horizontal or drooping branches, while scions made from the watershoots developing on the main stem will produce a normal growth. More recently it has been found that grafts from upward growing lateral branches having a form intermediate between the two described make plants which are noted for their strong development. On the whole it seems that the growth direction of the branch providing the scion will be reproduced in the grafted plant. In certain clones lateral growth is stronger than that of the watershoots. Surprisingly good results have been obtained in Java in the conversion of low yielding

trees by the use of these scions. The low yielder is decapitated and of the subsequent watershoots that arise the most suitable is grafted at a convenient height with one of these strong growing laterals. It is claimed that thus treated unprofitable trees have become heavy bearers. The necessity for replacement with a young tree which will probably be half smothered by its fully-grown neighbours is thus obviated and an earlier yield obtained.

Tested clones should when possible be used to provide scion wood. Wood taken from the best trees in the plantation does not always make the best clonal material. On the other hand it is a matter of history that poor yields attributed to unsuitable combinations of stock and scion have turned out to be a result of monoclonal plantings and consequent absence of cross-pollination (*arabica* excepted). Apart from the question of compatibility some scion clones (e.g. hybrids) are more amenable to grafting than others (e.g. *excelsa* types), nor will a tree that produces good erect scion wood necessarily be a success with its laterals, or *vice versa*. Other
18 suggestions for turning this polarity to practical account are made by Gandrup. If the top of a coffee tree breaks, it can be grafted with a lateral scion which will at once give a horizontal growth, rather than with the usual watershoot which might elongate to an inconvenient height before branching ; another suggestion is to build up a tree with lateral scions of different clones to ensure cross-pollination, particularly of the lower branches, which possibly from their position are less likely to receive foreign pollen.

Graft Covers. Some kind of cover, especially when wax is not used, to prevent the graft from drying out, has usually been found necessary, since coffee scions seem particularly susceptible to this and in experimental work the covered grafts have almost always provided the highest percentage of success. Various materials have been used including glass tubes, paper, banana leaf petioles, sphagnum moss and split bamboo. It may be noted that references to graft covers occur in most accounts of grafting technique.

16 *Glass Tubes.* If these are used, test tubes will do. The grafts will have to be shaded.

Paper is usually made into cylinders and waxed. These collars extend from above the tip of the scion to below the union. They can be filled, if thought desirable, with a moist moss, sawdust or fibre. In Java red paper is found to give better results than plain ; sometimes the cylinder is drawn in at the top except for a small aperture through which the scion can push, or instead the scion tip may be waxed.

43 *Banana Leaf Petioles* have to be changed at least once before union or they contract and press upon the scion and may cause it to fail.

Sphagnum Moss is bound round the graft from the union to the extremity ; it will require occasional watering.

Bamboo. The halves of a split bamboo are tied round the graft, which is not waxed.

Cuttings. *Soft Wood Cuttings.* Considerable work on the raising of *arabica* plants from
45 cuttings is in progress both at the Lyamungu Coffee Research Station, Tanganyika Territory, and at the Scott Agricultural Laboratories, Kenya, and much of the information in this section has been provided through their investigations.

The workers in Tanganyika have been very successful in the rooting of soft wood cuttings and consider the method they have evolved to be most promising for
20 supplying clonal material with the least delay. In March 1938, what is believed to be the first coffee field experiment in which the material consisted entirely of rooted cuttings was laid out at Lyamungu Research Station.

19, 45 The best type of soft wood cuttings are made from the leader and sucker growths, 4-6 inches long, of unshaded plants with short internodes, providing three or four

48 nodes to a cutting. When the suckers are growing rapidly, however, it may be necessary to take slightly longer cuttings to obtain the necessary firmness. Such cuttings may not callus so quickly as those from shaded plants but they show less tendency to rot. Shoots from shaded plants are distinguishable by a flatness of the stem persisting down to the fourth or fifth node for deeply shaded plants, or to the second or third node for those under lighter shade, while shoots from unshaded plants are round-stemmed. The position and type of basal cut was found to be of little importance. The leaves may be trimmed or not but should not be entirely removed, the amount of leaf surface left being proportionate to the stem.

20, 45 Any side shoots on the stem of the cuttings are removed. They wilt easily and their wilting affects the rest of the cutting. Rooting has taken place in 4-6 weeks, but in large scale work the average time required is 18 weeks. The roots are produced only from the callus and not before a complete ring of callus has formed on the cutting base. These cuttings are raised in specially constructed concrete propagating frames 3 feet by 3½ feet and 4 feet deep, 2 feet being below ground level. They are covered with glazed lights on which cheese cloth is tacked, the whole being surmounted by a framework of angle iron 4 feet above the glass to carry movable canvas blinds.

48 Formerly the glass was whitened, but a recent report mentions that after reducing the amount of shading to a single hessian cover which serves only to ward off direct sunlight, dying off became much less frequent and this is now the accepted practice. Bottom heat is unnecessary, the cuttings rooting best in the cool season.

20 The relative humidity is maintained at 90° and the average temperature is 73°-77° F. The most successful rooting medium of the many tried was a mixture of one part leaf mould to one part and. A mixture of peat moss litter and sand gave quicker callusing than any other.

Material for soft wood cuttings can be procured from suckers obtained by pegging down the main stem of young plants or by cutting back older plants to half their height. In each operation all primaries are removed. Stumping old or young plants gives inferior results in the number and rate of production of suckers. Adventitious suckers from mature trees occasionally had to be used but are not considered good material. The rooting material is well watered before the insertion of the cuttings and not again until the cuttings are rooted, the necessary saturated atmosphere being maintained by a mist spray given every morning and evening. The opening of the frames for this operation provides sufficient ventilation in addition to that obtained through grooves cut in the top of the concrete wall as an outlet for surplus moisture.

12, 45 *After-Treatment.* The rooted cuttings are potted in a compost consisting of the rooting medium plus a little ordinary soil and are gradually hardened off in a frame or greenhouse. They should be sufficiently established in a fortnight to permit of removal and may then be stood under shade until required for planting out.

22, 29 *Kenya.* At the Scott Agricultural Laboratories the installation of a new block of propagators in 1938 has enabled considerably more work to be done on this branch
29 of vegetative propagation. A communication states :—" The new propagators have been designed to try and overcome as far as possible the diurnal temperature fluctuation which is about 30° F. Bottom heat is supplied by two soil-heating cables originally controlled by thermostats. The thermostats, however, have not proved satisfactory owing to excessive lag in switching on or off, and to corrosion : temperature is therefore controlled at present by hand switches, and a soil temperature of about 75° F. is maintained.

The rooting medium used is 50 per cent. peat moss and 50 per cent. coarse sand (size of grain 1-2 mm.) ; this medium has given the best results in experiments

carried out to test different media. It drains well but not excessively ; moss and algae do not thrive on it ; rooted cuttings are easily removed without breaking roots.

There are two types of cutting which usually root successfully—(*a*) etiolated suckers which occur under dense shade in the centre of the tree : they are of hard, thrifty wood with very long internodes ; (*b*) rather stunted suckers which occur on the extremities of bent over verticals. These are also of hard and thrifty wood but the internodes are very short, and they grow in an exposed position.

Only the terminal growths are made into cuttings and the terminal bud is always left on ; as much leaf as possible is also left on. Leaf and terminal bud have the effect of checking premature vegetative growth of the cutting in the propagator. Cuttings vary in length from 3 inches to 7 inches. Propagators are syringed once or twice daily according to the weather ; this is sufficient to keep up humidity in air and rooting medium. Cheshunt compound is used to check damping off in the cuttings, but little trouble is experienced in this direction, unless the temperature rises excessively.

The time that coffee cuttings take to root is one of the main difficulties in this work. If a batch of clonal cuttings is put in the propagator, they start to root in ones and twos after four months or so ; this desultory rooting usually continues over a year or more. All cuttings are treated with a growth substance before being set in the propagator. The fact that cuttings take so long to root and there is so much variation in the time of rooting makes the production of cuttings expensive and difficult. An experiment is in progress to find out whether the time of year at which cuttings are taken from the parent tree has any bearing on the speed of rooting and number of cuttings rooted ; only negative results have been obtained so far.

A trial with cuttings grown under different colours of light has had interesting results which may go far towards solving our problems. It was decided to try to root cuttings under red, yellow and blue light. As it was impossible to obtain clear coloured glass in Kenya, coloured cellophane placed between two sheets of glass was used for this experiment, colourless cellophane being the control. Thirty-six clonal cuttings were treated with a growth substance and were divided into four lots of nine, one lot for each colour and one for the control. The cuttings were set out on February 2, 1939. On the same date a seedling plant of *Carica candamarcensis* Hook f. was placed under each light ; the height of each plant being 8 inches. The experiment is not quite completed but the results on June 24, 1939, were as follows :—

Colour of Cellophane	No. of cuttings alive but unrooted	No. of cuttings rooted	No. of cuttings dead	Growth of *Carica* plants
Red	6	0	3	4 in.
Yellow	3	6	0	14 in.
Blue	8	0	1	10 in.
Control	7	2	0	2 in.

The result shown by the yellow cellophane is very promising ; the remaining unrooted cuttings in this treatment show every sign of rooting in the near future. It will be necessary to repeat the experiment with a larger number of cuttings to confirm this result."

22, 9 Pre-treatment of the cuttings with various gases failed to stimulate rooting. Elsewhere when specially constructed frames have not been available bell glasses or cloches over a suitable rooting medium have made fairly adequate substitutes. It is important with these to give occasional ventilation and to avoid excessive drip from the condensation of moisture. *Arabica* and *canephora* are said to be the most amenable. An elaboration of this method by which a few cuttings at a time could be rooted has been used in Java with much success. A small inverted flower pot was placed on good drainage material (crocks or sand) within a larger pot in such a manner that its inverted base came level with the rim of the larger pot ; the space between was filled with sand ; the cuttings were inserted in this and the whole covered with a bell cloche and plunged in a bed of sand or ashes to the rim to maintain the moisture.

Damping off in the propagating frames can often be checked by the use of Cheshunt compound.

40 In Java, *Conuga* and *robusta* coffee are regularly rooted by the methods used in Tanganyika. In Java the glass frames are covered with a white material resembling muslin, which is kept permanently moist by the leakage of water through perforations in a bamboo pipe running along the back of the frame (the lights slide under it). The pipe is fed from drums into which water is pumped as required. The moisture thus provided reduces the temperature in the frames from 95° F. to 84° F., making the difference between life and death for the cuttings. The cuttings themselves are lightly sprinkled twice daily. The white cover is only used on sunny days and then only from 8 a.m. to 3 p.m. Two metres above ground or 1·20 m. from the top of the frame at its highest is a lattice work roof made of interlacing bamboo strips 19 mm. wide with 17 mm. intervals. This is supposed to admit a quarter of the available sunlight. The essentials for success are plenty of light evenly diffused, combined with a cool temperature. The cuttings used are the upper portion of the shoots and consist of two or three joints and are 9-12 inches long (i.e. some inches longer than is customary with *arabica* in Tanganyika and Kenya). Shorter cuttings usually die as do older ones. A shoot may make two cuttings but never more. Great care is taken to guard the leaves of the cuttings from damage during transport which is often from a distance. Damaged leaves soon fall and leaves without cuttings will not strike. In two months the cuttings are lifted for examination and those that have rooted are planted in baskets and kept under glass a further month and then stood out in the shade. In the rainy season the extra month under glass is dispensed with. In six months from the time it is made the cutting should be ready for planting out. The rainy season brings a reduction in rooting percentage and this is attributed entirely to reduced light—apart from *Rhizoctonia* attack which is then usually troublesome.

Rooted cuttings are not ready to be used as rootstocks for about a year. They can, however, be grafted at the time the cutting is made ; the successful takes (about 50 per cent.) are much lower than on rooted stocks, but the method enables clonal stock/scion combinations to be made at will and without delay. It is immaterial whether the basal cut is made above or below a joint. There are marked clonal differences in ability to root.

44, 45 *Hard Wood Cuttings.* In Tanganyika these have proved less satisfactory than soft wood cuttings. The rooting percentage (50 per cent. in Tanganyika) is lower, the time required (3-6 months) is longer, and the percentage of loss on transplanting is higher (10 per cent. soft wood, 40 per cent. hard wood).

22, 23 Research stations in South India and Kenya report similar results. In the latter country, however, in a district with a heavy rainfall a planter has been very successful with cuttings 2 feet long and 1-1½ inches in diameter made from the

prunings of trees grown on the multiple stem system and set in the open ground. They are reported to be producing a prolific root system.

39 On the Ivory Coast hard wood cuttings of *canephora* 8 inches long were in transit for five days and subsequently succeeded to the extent of 75 per cent. This was by no means an isolated example. In this same district is a native plantation grown from sections of hard wood 4-5 feet long and 3 inches thick, planted erect and in groups of three. Eighty per cent. of the number of groups were successful, i.e. had at least one cutting that rooted. The method is one frequently used in the district.

39 At Bingerville, on the Ivory Coast, experiments with hard wood cuttings of seventeen varieties (not all distinct species) were carried out during August 1934 (in the short dry season) under the following conditions. The cuttings were 8 inches long and a half to three-quarters inch thick. The lower end was cut on the slant and the upper end cut straight across and waxed. The cuttings were planted upright in light sandy soil worked to a depth of 6 inches and given a mulch of dry bamboo leaves. Regular waterings were given, daily the first week, then every three days. The results were recorded in the following November. A *liberica* from Buitenzorg, Java, was the most successful with 83 per cent. while a local *liberica* had only 28 per cent.; *canephora* from different districts varied from 67 to 22 per cent. except in the case of a self-sown plant which registered only 4 per cent. The hybrid *congensis* × *Uganda*, from Java, 51 per cent., local *arabica* 7 per cent., *stenophylla* 13 per cent., *Arnoldiana* from the Belgian Congo 36 per cent., the only *excelsa* gave 1 per cent. but an *excelsa* type Gros Indénié gave 28 per cent.

50 In Uganda large woody cuttings inserted in nursery beds and kept shaded and watered have given fair success.

21 In Kenya and elsewhere the root systems of trees grown from cuttings have been found to be fully equal to that of seedling trees of similar age.

Budding and Grafting Hard Wood Cuttings before Rooting. Rapid union was formed both with grafts and buds, the latter requiring the protection of waxed tape to prevent rot. The slow rooting of the hard wood cuttings has, however, been a handicap since the scions which shoot rapidly later often die off in the absence of roots on the stock. Should this slow rooting be overcome the method is regarded as being one which will prove very useful in the rapid production of clonal material.

21, 45 *Root Cuttings, Leaf Cuttings, Leaf Buds.* Attempts to root these types of cutting in various media, at the Coffee Research Station, Tanganyika, and in Kenya, met with no success.

Growth Substances. Much work has been done at the Scott Agricultural Laboratories on the treatment of cuttings with growth substances, and a new technique for the injection of these substances into cuttings has been evolved. It is as

24, 25, 29 follows :—

" The solution of the growth substance is placed in a vacuum desiccator, and the bases of the cuttings are stood in the solution ; the lid is placed in position, and the air exhausted to a negative pressure of 60 cm. of mercury. The vacuum is maintained for a period of from 5 to 10 minutes during which time air is drawn from the interior of the cuttings and bubbles up through the solution. On releasing the vacuum, the solution takes the place of the air extracted from the cuttings, which are allowed to absorb the solution for from 5 to 10 minutes.

Not only does this method reduce the time of treatment from 12-18 hours to a few minutes, but where large batches of cuttings have to be treated, it effects a considerable economy in the amount of solution used because the same solution can be used many times over.

An experiment to test this technique against the ordinary method of treatment using different strengths of Hortomone ' A ' was started on August 17, 1938. The experiment is not completed but results obtained up to June 24, 1939, are interesting. Four strengths of Hortomone ' A ' were used, and two treatments for each strength :—

1. Cuttings stood in solution for 18 hours.
2. Cuttings stood in solution and subjected to 10 minutes' vacuum followed by 10 minutes' absorption.

The results obtained up to June 24, 1939, are shown in the table below :—

	Treatment		*Rooted*	*Dead*
A	Hortomone A at 1 : 50,	18 hours treatment	3	8
B	Hortomone A at 1 : 50,	vacuum treatment	4	1
C	Hortomone A at 1 : 100,	18 hours treatment	4	3
D	Hortomone A at 1 : 100,	vacuum treatment	4	1
E	Hortomone A at 1 : 150,	18 hours treatment	0	2
F	Hortomone A at 1 : 150,	vacuum treatment	4	1
G	Hortomone A at 1 : 300,	18 hours treatment	1	2
H	Hortomone A at 1 : 300,	vacuum treatment	6	1
	Total for	18 hours treatment	8	15
	Total for	vacuum treatment	18	4

It is not possible to draw definite conclusions from these results as they are not complete, but at the moment it appears that the vacuum treatment produces results far superior to the 18 hour treatment.

An experiment to test the efficacy of vitamin B_1, as a root promoting substance when used in conjunction with Hortomone ' A ' as a root hormone is in progress but results at present are disappointing, the control cuttings rooting better than the treated."

20, 46 In Tanganyika, experiments were carried out with Hortomone A in various concentrations. No significant results were obtained, but the indications were that Hortomone A accelerated rooting. There was, however, a strong suspicion that the difference in capacity to root between different trees was greater than the general response to root-promoting substances.

40, 41 In recent experiments in Java the application of growth hormones in water through the cut stem bases was useless and even harmful. A continuous feed of a lanolin hormone mixture maintained at the cut, upper end was more useful. Though not a completely efficient substitute for the removed top it was very much more successful than the topped, untreated controls.

48 Suitable cuttings are not always easy to obtain.

Clonal Cuttings. A method of producing clonal cuttings has been evolved at Tanganyika Coffee Research Station. Rooted clonal cuttings are planted out 4-5 feet apart and allowed to grow up on the multiple stem. When sufficient growth has been made the unwanted primary branches are removed and the remainder pegged down along the ground. Suckers will start at the nodes and provide a quantity of suitable material for cuttings. The top of the stem is retained to draw the sap the full length of the plant and this can be pegged down again at a later date.

Layering, Etiolation. 21, 22, 45 Suckers growing from a stumped tree will usually root if ring barked at the base and then etiolated by mounding. A development of this method similar to that practised with plum stock at East Malling enables large quantities of plants to be produced. A rooted cutting is planted at an angle of 25° to the ground. As it grows it is pegged down and produces erect suckers from the axillary buds. When 12 inches high these are ring barked or ring wired or split at the base and

the soil drawn up round them (mounding). When rooted the suckers are removed, the parent plant then producing others.

A number of suckers instead of removal from the parent plant should be laid down at right angles to it to form a wider area of production. Before mounding the basal wood of the suckers should be quite hard.

2 Layering of *robusta* stocks at Amani resulted in root development from the main stem and very few roots from the base of the suckers. A few such shoots were successfully transplanted with hammer-shaped rooting portion at base. Attempts to root *arabica* shoots by layering have failed.

19, 45 At the Coffee Research Station in Tanganyika *arabica* was layered but here also the roots mostly developed from the main stem even when the shoots were layered or ring wired. There were many losses on transplantation.

Marcotting. This is easily accomplished during the rainy season especially with *C. canephora.*

9 The plants should be sufficiently rooted for detachment from the parent tree in 2½-3 months. It will be safer to grow on in pots under light shade for a few months before planting in the field.

When the plants have become well-rooted in their permanent positions it is advisable to cut them back in order to obtain a measure of rejuvenation by means of sucker growth, the strongest of which is retained to form the tree.

Suckers. Certain varieties such as *C. canephora* throw up suckers from ground level. If the

9 earth is drawn up round these they will emit roots and in a few months can be detached.

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COLA NITIDA A. Chev. **C. ACUMINATA** Schott & Endl. (*Sterculiaceae.*) Cola Nut. Kola.

2 *Cola nitida* A. Chev. and *Cola acuminata* Schott & Endl. are sources of cola nuts in West Africa. The two species are closely allied, with similar leaf and flower characters, but are distinguished from one another by the fact that in *C. nitida* there are two cotyledons and in *C. acuminata* more than two cotyledons. *C. nitida* has a more westerly range than *C. acuminata* and is a typical species in the forests of the Gold Coast, Ivory Coast and Liberia. The nuts of *C. nitida* are more appreciated and are said to contain more caffein than those of *C. acuminata*. *C. nitida* is the species almost solely cultivated by Europeans in West Africa and furnishes most of the nuts in European commerce.

Cuttings. 4 In experimental work in Trinidad with *Cola acuminata* a reasonable proportion of soft wood cuttings taken from terminal and lateral shoots, which had just matured after a flush, callused in one week and rooted in 6-10 weeks in a solar propagator. The cuttings were about 4 inches long, the lower leaves only being removed and the remainder left untrimmed. The successful rooting medium was a coarse-grained calcareous beach sand. A closer-grained, non-calcareous sand from an inland site was not a successful medium. In each cutting a single root emerged in a slanting direction above the lowest point of the oblique cut. The root direction soon became vertical and lateral roots appeared, the older parts of the main root gradually growing hard and corky. The cuttings were potted when the main root was 2-3 inches long.

3 Attempts on the Ivory Coast to root *Cola* from cuttings of ripened wood set in the open under shade resulted in the rooting of only 15 per cent. Success was apparently hindered by a resinous exudation.

Layers. 1 In parts of Africa the drooping lower branches are pegged down so as each to touch the ground in two places (a form of serpentine layering). Roots appear at both places of contact and by subsequently cutting between them two rooted plants are obtained instead of one.

Root Suckers. These may be removed from the parent tree and will often grow.

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COLOCASIA ANTIQUORUM Schott. (*C. esculenta*) (*Acaceae*). Eddoes. **XANTHOSOMA SAGITTIFOLIUM** Hort. (*Acaceae.*) Tania. Taro.

1, 2 For all practical purposes eddoes and tania may be considered the same. They have in fact been considerably confused in the literature. *Colocasia* has a peltate leaf and *Xanthosoma* a sagittate leaf.

Tubers. The head of the root is cut off when the plants are lifted, with a few inches of the lower part of the leaf stalk attached. These heads when planted put out buds and so form new plants.

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CURCUMA LONGA L. (*Zingiberaceae.*) Turmeric.

1, 2 Turmeric is propagated by sets or small pieces of the rhizome. In the dry season the rhizomes can, if necessary, be stored in clamps under soil until the rains, when they can be divided into suitable sets and planted.

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DERRIS spp. (*Leguminosae.*) Tuba Root. Derris.

7 In every country where *Derris* is grown the selection of strains having a high rotenone content is a main objective, since at present the percentage of rotenone determines the market value.

At the time of writing the Dutch in Java claim to have selected two forms of salient merit in this respect, Toeba poetih Ct. and Toeba woeloeng L.C.B., which possess a rotenone content of 8-10 per cent. and 11·3 per cent. respectively. Both these selections are undergoing intensive propagation for early distribution, the first at the Cultuurtuin (Ct.) at Buitenzorg and the second by the Lands Caoutchoucbedrijf (L.C.B.).

Maas states that T. poetih Ct. was selected from material obtained in 1927 from the Serdang Experiment Station, Malaya, and our information is that it is a very low-growing form of *D. elliptica* Benth.

T. woeloeng is a variety, possibly indigenous to Java, noted for its superiority as
6 a fish poison over the other local forms of *Derris*. The L.C.B. form is a selection of a plant or group of plants of this variety. It most resembles the Changi No. 3 form of *Derris elliptica* described by Henderson.

The leaf tips are blunt or quite rounded and the reddish-brown hairs on the underside are usually prominent, not only in the young but also in the mature leaves. The number of leaflets is from 9 to 15. The evolution and selection of high-yielding strains of *Derris* is, of course, in active progress at agricultural research stations of Malaya, Ceylon, Tanganyika and elsewhere. The work in Java is mentioned in detail in view of the success claimed and because such information is not always easy to obtain.

2 Barrett seems to express a doubt as to whether the high rotenone percentages of selected clonal stock will be maintained under prolonged intensive cultivation without frequent reselection.

Cuttings. Propagation is by stem cuttings usually from 12 to 18 inches long. The actual
1, 2, 3, 4, 5, 8, 9 length, however, appears to be a secondary matter, since an old stem may carry many more dormant buds in a given length than a young vigorous branch. In the latter case two- or three-joint cuttings are used, the three-joint being preferred by some on the score of presumably greater vitality.

Mature wood from plants 1-2 years old is likely to be the most suitable, though soft cuttings from the tops of shoots can be used with success under controlled conditions of shade and humidity.

In cuttings of mature wood the roots start from whitish lenticel-like pustules on the internodes, the position of the basal cut being therefore immaterial. The cut at the upper end may also be made without special precautions. It is usual to make the cut at an angle of 45°.

In wood not fully matured the basal cut should be below and close to the node and the apical cut should be above and close to the uppermost node. If a length of internode is left at either end with this type of wood the soft pith shrinks or rots and the whole cutting may perish.

The cuttings may be set as soon as made to two-thirds of their length in shaded nursery beds of light sandy soil and kept moist, which can be done effectively by means of a mulch or covering of grass or light trash and an occasional watering. Under these conditions cuttings should have rooted in three weeks and be sufficiently advanced for transplanting to the field in six weeks.

If cuttings are to be set directly into the field it is advisable to allow them first to callus by stratifying them in a cool place for about ten days in shallow layers in damp peat or sphagnum, or they may be wrapped in very damp gunny sacking or similar material. Such cuttings when planted unrooted in the field are helped by a handful of sharp sand placed around the base, by the removal of the leaves and by the protection of the tip by means of a bunch of grass, moss or foliage. As in the case of nursery setting, two-thirds of the cutting should be below ground.

1 A recent experiment in the Philippines in monthly field planting of unrooted *Derris* cuttings (including *D. elliptica*) in which most of these precautions were omitted resulted in very heavy losses even during the wet season and under natural shade.

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DIOSCOREA spp. (*Dioscoreaceae.*) Yam.

2 When the yam is ready to be dug up the tops are cut off with the vine attached, and the tubers lifted. The top is then replaced in the soil and with the base of the stem is mounded up with good soil. In three months another yam, called the "head", is produced. The head is then cut into pieces each containing an eye from which the new plant develops.

3 The aerial tubers found in some species are also used for propagation.

Cuttings. 1 Cuttings present no difficulty but the first described method is preferred.

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DIPTERYX ODORATA Wild. (*Leguminosae.*) Tonka Bean.

Budding. 2 In Trinidad the rectangular patch bud is used with success ; other methods also give fairly good results.

Grafting. 2 The Tonka bean is easily grafted.

Marcots. 1, 2 Marcotting succeeds with a moss covering, especially in the rainy season. The attachment of a water reservoir and a wick for keeping the moss moist is of use in this method. A further improvement consists of the envelopment of the mossed portion of the branch with a covering of bamboo stem, such as the two portions of a longitudinally split bamboo section, filled with good loam. The roots push through the moss into the loam and grow rapidly without drying. Adequate rooting usually takes six weeks.
When girdling the branch for the marcot about 2 inches of bark should be removed.

Rootstocks. 2 So far only seedling rootstocks have been used. A dwarfing stock would be very useful.

Cuttings. 2 Cuttings will strike if given attention.

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ELETTARIA CARDAMOMUM Maton. (*Zingiberaceae.*) Cardamom.

Rhizomes. 1, 2 Pieces of rhizome bearing not less than three shoots are used and require careful handling and shallow planting.

These rhizome-cuttings, sometimes called "bulbs" may be removed from the non-fruiting stool by digging under the plant and breaking off the rhizomes. This practice, however, often causes a severe check on the mutilated side of the plant. A better method is to lift the selected stools and break them up into suitable planting material.

References

1 Nicholls, H. A., and Holland, J. H. 1929. *A text book of tropical agriculture.* Macmillan, London.

2 Ridley, H. N. 1912. *Spices.* Macmillan, London.

ERYTHRINA INDICA Lam. (*Leguminosae.*) Immortelle.

Cuttings. In the Philippines cuttings of *Erythrina indica* planted, as shade for coffee, in the field when from 1 to 3 feet long furnished 1 sq. yard of shade in six months.

Reference

Opeña, P. P. 1935-6. Studies on propagation of three shade trees for coffee. Abstracted in *Philipp. Agric.*, 24 : 899-90.

EUCALYPTUS MACULATA var. **CITRIODORA** Bailey. (*Myrtaceae.*) Lemon-scented Eucalyptus.

From Russia, where there is now considerable research on plants likely to yield the more valuable essential oils, comes an account of the rooting of cuttings of *Eucalyptus citriodora,* a plant hitherto exclusively grown from seed.

Cuttings. The cuttings were rooted under glass without much difficulty. Details of rooting medium are lacking but the plants rooted equally well whether in pots or boxes in about two months. Cuttings did best from short internode plants. These were first obtained accidentally by growing the plants under short day conditions. Plants grown under long day conditions had larger leaves and higher oil content but were also less suitable for this method of propagation.

Reference

Larina, A. K. 1939. Experiments in the propagation of *Eucalyptus citriodora.* (Russian.) *Soviet Subtropics,* 1938, Nos. 2-3 (54-5), pp. 51-3.

EUCOMMIA ULMOIDES Oliver. (*Eucommiaceae.*)

1, 2 A gutta-producing plant, native of central and west China, now under investigation in Russia. In Russia, plants from seed seem to be almost exclusively female, making some form of vegetative propagation a necessity.

Grafting. The surface roots can be cut up and successfully grafted by many methods before the sap rises in early spring. Scions may be taken from year-old plants, the centre part of the shoot having the best buds. The graft is then set in light soil under glass and kept watered and shaded. Growth starts in 20 days.

Cuttings. Green shoots carrying two to three leaves are used as cuttings and root under glass (about 80 per cent.) in 35-40 days. The leaves are cut to half their length to reduce transpiration. They are said to require expensive care in the preliminary stages of growth, being grown in pots and repotted twice and needing constant attention. An attempt to force resting plants into growth for the early supply of cuttings seriously weakened the parent plants.

Root Suckers. The surface roots, cut in spring into sections about 4-5 inches long each with an eye or young shoot, and planted in frames kept shaded and moist, produce root and shoot growth in 7-10 days. By August the shoots are up to 4 feet high and may be used for layering in the autumn or following spring.

Layers. Plants for layering are planted at an angle of 45° to the south so that the sun's rays strike them at a tangent. Spacing is 4 to 6 feet apart in the rows. The main shoots in autumn and spring are pegged down on the soil, side shoots being removed. The buds of the prostrate stems produce vertical shoots. When the shoots are 4-5 inches high the branch is removed, placed in a trench 3 inches deep and covered lightly with soil. Roots develop under each shoot very rapidly and in the autumn the branch is dug up and the rooted shoots removed from it for planting.

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EUGENIA CARYOPHYLLATA Thunb. (*Myrtaceae.*) Clove.

Attempts to propagate the clove other than by seed have been consistently unsuccessful for practical purposes, though the Agricultural Department of Zanzibar have given the matter careful study.

Budding. 5, 6 Has in no instance been successful.

Grafting. 5 Approach grafting in Zanzibar has resulted in a few unions of which only one sickly plant survives.

Rootstocks. 6 In addition to failing on its own stock the clove has also been unsuccessfully worked on *Eugenia cauliflora, alba, cordata, edulis, Jambos, uniflora, rupestris, myrtifolia, Smithii.* These species were imported into Zanzibar in collaboration with Amani in the hope of procuring a satisfactory dwarfing stock.

Cuttings. 2 At the Royal Botanic Gardens, Kew, the clove has been rooted from cuttings of small lateral shoots taken with a heel and inserted in a propagating case in a compost comprising 90 per cent. sand and 10 per cent. leaf soil.

Layering. 3, 4 Nicholls says that if the young branches are layered and kept moist they will root in about 6 months. This has also been done successfully in Zanzibar.

Marcots. 1 These are said to have occasionally succeeded.

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GLIRICIDIA SEPIUM (Jacq.) Stend. (*Leguminosae.*)

In the Philippines cuttings of *Gliricidia Sepium* 3 feet long, planted in the field as shade for coffee, furnished 1 sq. yard of shade in 9 months.

REFERENCE

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HEVEA BRASILIENSIS Muell. Arg. (*Euphorbiaceae.*) Rubber.

Budding. 1, 10, 11, 13, 18, 23, 36

Budding has proved to be the only method suitable for vegetatively propagating *Hevea brasiliensis* for commercial plantations.

Patch budding, modified Forkert or a form of the latter in which the flap of bark on the stock, instead of being partly trimmed back, is retained *in toto* for covering the inserted bud are the methods used.

A variation, said to be standardized in Indo-China, consists in peeling the bark of the stock from below upwards instead of in the reverse direction as is usual. Advantages claimed are a better protection against the entry of rain water into the wound, less trouble with latex flow and, with older stocks, less frequent breakage at the union. With this technique buds need not be bound with a waterproof tie.

18, 36 A precise and well-illustrated description of the current method of budding *Hevea* is contained in Planting Manual No. 8, 1939, issued by the Rubber Research Institute of Malaya. The technique will be found to have been modified in several directions since it was described by Summers in 1930. Some of the more important details of the current method are given below.

20 A number of pertinent observations by Mr. C. E. T. Mann of the Rubber Research Institute, Malaya, who kindly scrutinized the section on Rubber, are also included both here and elsewhere in the section.

The method in use is the Forkert, but with the flap wholly retained. A preliminary incising of the bud patch some few stocks in advance of the budders to allow of coagulation of latex is now only considered necessary with budders under instruction. A reasonably efficient budder can work fast enough to complete the whole operation before the flow of latex from the edges of the panel is sufficient to endanger the success of the operation.

After the bud has been cut and *trimmed ready for insertion* the chip of wood at the back must be carefully detached. There should then be visible at the back of the bud a minute projecting peg and a corresponding hole in the wood opposite. If the centre of the bud remains on the wood, leaving a hole in the patch, the bud patch is useless. The bottom 6 inches of the stock is now cleaned down to the collar with a rough cloth, the necessary cuts are made sufficiently spaced to leave one-eighth inch margin at top and sides of the bud patch, the bud is inserted and the flap rapidly pulled up over the bud by the aid of the tie strip, it being understood that the wood of the panel must not be rubbed or touched with the hand and that no dust or latex should be allowed on the contact surfaces. The binding of the panel after insertion of the bud is usually begun at the top. The first turn of the waxed bandage clips the top of the flap into its original position and holds the patch securely without risk of lateral squeeze during the later stages of the binding operation. After one turn securing it to the top of the panel the bandage is carried in a long spiral turn to the base of the stock and the binding is completed upwards with the quarter to half inch overlap finishing just above the first securing turn. The free edge of the bandage is pushed with the point of the knife smartly into the soft bark above the panel, a spot of latex exudes, coagulates and so secures the tie. Many budders smooth down the completed bandage with hand or knife back. This should not be necessary if the bandage is expertly put on. Shading is essential when budding is done in the field, but is

not necessary in the closely planted nursery where buddings are prepared for transplanting. The shade is effectively given by a few leaves taken from the stock itself and tied over the bud patch with old binding strips. When opening the bandage 14-21 days later only the portion of the flap covering the bud is cut off. This obviates the necessity of applying any protective substance to the exposed edges of the panel.

27 Buds which were apparently successful would often die after the tie had been loosened. This was controlled by anointing the edges of the union with paraffin wax or a wound paste immediately on opening the tie. The exact position of the patch beneath the flap covering the panel can be plainly seen on removing the bandage. The leaf shade is replaced. Seven to ten days later further examination is made and the viability of the bud is tested by lightly scratching the shield above and below the bud. If the bud is alive the stock is cut off about 2 inches above the top of the budding panel. The shading must now be renewed. Both shade and protection in a reasonably durable form is provided by a split bamboo about 18 inches long inserted in the ground about an inch from the bud. This
20 also ensures the vertical growth of the bud shoot. It may be removed when bud growth reaches the top. In Java shading is done by means of a bottomless bamboo basket placed over the stock and pegged to the ground.

It might be added that cutting back of the stocks of successfully budded plants may be delayed for several months if desired. This is often seen in large commercial nurseries where large supplies of budded stocks may be steadily prepared by a small gang of expert coolies working over a long period in readiness for transplanting to the field. In transplanting the plants are loosened by digging to a depth of about 12 inches, then pulled and tap roots trimmed off at 2 to $2\frac{1}{2}$ feet. The lateral roots are pruned to about 6 inches and the stock neatly severed at about 6 inches above the grafted bud. The "snag" provides a useful handle for transplanting; the cut end is dipped in just-melted grafting wax (or smeared with white lead paint) to prevent water loss from the freshly cut vessels. Treatment
6 with plant hormones before planting has given very promising results.

16 A considerable increase of speed and a reduction of costs was obtained in Java by dividing the different operations required in budding between the members of a gang. Thus 1,500 buddings per day were made by a gang composed of three men for cutting the buds, six men for inserting them and giving a temporary tie, three men for incising the stock, six women for tying. In this connexion Mann may again be quoted :—

20 "Although the team method met with some success in the early days we have found as a result of later experience that it is preferable to select the most apt coolies, and the standard of individual ability, especially among Chinese, is extremely high. We have experienced Chinese who, given good material to work with, can make over 300 buddings per day working for about 6 to 8 hours with over 90 per cent. successful takes."

19 Mann, in his investigations on budding in the field, shows that success is influenced by the personal factor even between skilled operators, by clonal differences and differences within the clone; that stocks in vigorous growth are more successful than dormant ones, and that drought conditions and especially the absence of shade after budding and after loosening the tie will greatly reduce the percentage of success.

33 Sharp, of the Rubber Research Institute, Malaya, conducting experiments with large stocks 32 months old, 12·5 inches in circumference at the collar, found that increasing the period before opening the tie from 18 to 23 days raised the success percentage from 69 to 82 per cent. No advantage was obtained by extending the period to 28 days. Opening at 23 days delayed the time of the shooting of the bud, but this was unimportant compared to the advantages gained.

34 In cutting back the snags of large budded rubber Sharp found that the steeper the angle of the cut the better and quicker the subsequent callusing. An angle of 50° was found to be the optimum. The steep cut on a large stock is more trouble to the workman, who in consequence will tend to the flatter cut if allowed. Treatment of the cut surface with the standard asphalt kerosene mixture caused delay and uneven callusing. Untreated trees healed very much better.

35 The budding of older trees has attracted some attention. In *De Bergcultures*, Vol. 10, correspondence is quoted dealing with a method of budding trees over 4 years old which is claimed to have been unusually successful. The trees were cut back when budded so as to leave a piece of stem 2-3 feet long above the bud. The new shoots arising from this stem were allowed to grow in order to promote a healthy condition. The presence of these shoots slowed down the growth of the new bud, and to provide a stimulus a right-angled strip of bark was cut from the stock above the bud. When the bud shoot had attained a length of about 10 feet the stump was finally cut back to above the union. The wound so made healed quickly.

9, 14, 38 From Java several experiments in budding trees up to 10 years old have been described. The buds were inserted three on one stock in the case of 10-year-old trees and two on a stock in the case of trees 6-8 years old. The stocks were headed back with an oblique cut to a short stub, subsequently removed, to which the growing bud was tied. In 10-year-old trees success percentages were not remarkable and those buds which grew often showed an incomplete union, probably on account of the great difference in bark thickness between bud and stock. With trees of 6-8 years old at least 80 per cent. had one bud growing after a few weeks which subsequently developed into a tappable tree. These buds became tappable 18 months earlier than buds on year-old stocks would have done. Buddings were made at heights varying from 8 inches to 2 feet above ground without any difference in effect on take or growth. The yield from these buddings on old stocks does not appear to be inferior to that of similar clones budded on 1-year-old stocks in the normal way. The method is useful for working over self-sown seedlings in the plantation to clonal scions.

20 Mann contributes a note on this work in Malaya :—" As far back as 1930 budding of 4-year-old trees was being done extensively on estates in Malaya. The position at that time was that many companies, slow to be converted to the advantages of budding and clone selection, found themselves with large areas of young seedling rubber consisting of ordinary unselected material at a density of 120 to the acre or less. The seedlings were about 4 years old, it was too late to consider interplanting with buddings, and planters were not sufficiently bold (or convinced) to scrap the lot and re-establish with buddings. Fortunately we at the Research Institute had already carried out successful trials of budding 4-year-old trees and estates continued the work on a large scale. Owing to the difficulty of budding at the normal level 2 to 3 inches from the ground, the height of budding was often raised, on large specimens to a maximum height of 3 feet. Many of these high-budded trees are now ' in tapping ', some are being tapped on ' stock ' bark below the union. Although the results are inconclusive at present I believe we shall soon have sufficient evidence to show that certain scions have a marked ' improving ' influence on the yield of the stock.

The method of budding several patches on a single large stock has been used successfully for the rapid propagation of ' bud wood ' of new clones."

28 At the Dartonfield Estate of the Rubber Research Scheme, Ceylon, fifty-eight 25-year-old trees were budded experimentally in August, a liberal manuring having been given and tapping stopped in the previous May. The bark could only be peeled satisfactorily on forty-three of them. On each tree two buds were placed on virgin bark and two on well-matured renewed bark. The results were poor and the method is regarded as commercially impracticable with trees of this size.

9, 14 *Root Budding.* An attempt was also made to bud on the roots of 10-year-old trees. Heavy rains however filled the holes which had been excavated to expose the roots and most of the buds failed. Those that succeeded were nearly all subsequently broken off by wind.

14 Van Helten describes a similar attempt. He had fair success but only when the following conditions, out of the many tried, were observed :—The bud patch was placed on the side and not on the top of the exposed root (or it rotted) ; the trees were 6 years old and over ; the root was not severed until 2 months after the bud had taken and then only very gradually at the rate of 1 cm. a day (with some roots the process took as long as 20 days) ; the transplanting was delayed until 6 months after growth had started, the material being then either stumped or having the green shoots only removed. The plants so obtained are now vigorous trees. Budding on short lengths of detached roots was a complete failure.

2 Budding on the old roots still attached to the tree with the idea of establishing a new tree on the existing root system was not successful in 1932, since d'Angremond then found that such buds were difficult to start and none were permanently successful.

20 Mann writes :—" Recently, further work has been done on root budding. The principal aim has been to discover a means of rapidly replacing an old played-out stand of mature seedling trees with new material. It was thought that, if scions could be successfully established on the vigorous root systems of existing trees, considerable reduction in the time between the eradication of the old trunks and recommencement of tapping on the new scion trunks might be effected. The root disease problem, apart from other practical difficulties, would appear to render this difficult. Complete replanting appears to be the best procedure."

2 A planter in Java succeeded in getting budded roots to shoot without actually severing them, but he had to make deep incisions two-thirds of the thickness of the root in depth to right and left of the bud.

Grafting. The usual methods of grafting have been tried with *Hevea* material with indifferent
20 success. The reason for the poor results obtained is no doubt to be found in the presence of latex in the phloem and cortical tissues of the stem. The flow of latex from the severed tissues prevents the intimate contact of the cambial zones which is essential for the successful union of the usual type of graft.

2 *Root Grafting.* A method of grafting in which the primary root of a young seedling plant (" stump ") is grafted to a large living root of an older tree, which it was eventually to replace, has been described from Sumatra. It was hoped by this method to reduce the malnutrition caused by the root competition and shade of the older trees. A hole was bored with a brace and bit through a thick root of the old tree and as far from the trunk as possible ; the young rubber stump was inserted in the hole so that its root passed through to the other side. The upper join was waxed, the lower left unsealed to permit the wound secretions to drain off. The root was then re-covered with earth. Thick stumps were found to be better for the work than thin ones. In all cases perfect unions were obtained but did not begin to form until 5 months after the graft was made. A year after grafting or 7 months after the union a definite increase was observed in the circumference of the stump grafts over the controls.

24 *Growth of Buddings.* Some observations made by Ostendorf in the course of experimental work in Java are not without interest. The length of the period which elapses between the date of transplanting or cutting back of a budded stump and the date when the swelling bud breaks through the cortex is a specific clonal property varying with the clone. This period is called here the *sprouting period.* The girth of the rootstock has no influence on the sprouting period. The first direction of growth of the young bud on the rootstock is not the same for all clones and hence may be used as a character for identification. The duration of

resting periods of growth and the length between the leaf storeys is a clonal specific character. Buds of clones with short resting periods give the best "takes". A distinct positive correlation exists between the length of storey and the number of leaves ; a smaller correlation between length of storey and leaf size ; a doubtful negative correlation between number of leaves and leaf size. The number of bud scales showed a positive correlation with the duration of the resting period. Damage to the root system had little effect on growth periods but the resting periods were lengthened in proportion to the amount of root damage. The degree of relationship between stock and scion had no effect on growth of scion except in one experiment and here it quickly passed off. The strongest buds show the shortest sprouting periods and subsequently the shortest resting periods, a fact to note when experiments on the length of sprouting periods are planned.

Scion Wood.

13, 36 The most suitable bud wood according to some writers is the brown or grey-brown wood which is usually over a year old. Light brown wood 7 or 8 months old has been experimentally proved to give greatly inferior results probably because it is more easily damaged. The most suitable buds, about 1 mm. in diameter, are glossy, with a rounded tip, and somewhat sunken on the bark. The best time to take the bud wood is when the shoots on the tree are making active extension growth.

24 Buds from clones which flush at short intervals show a higher percentage of takes than those from clones with less frequent flushes. Buds from the axes of the lowest leaves of a bud stick appear to start into growth more quickly than those from higher up.

33 Sharp found, at least in budding old stocks, that brown wood gave the best results in actual percentage of successful takes but that the semi-mature wood gave buddings which sprouted more quickly than those made from older bud wood.

20 Late sprouting may be quite troublesome (in field experimental work particularly) with certain clones.

To obtain an "even break" it is sometimes advisable to select young bud wood in preference to older and otherwise more satisfactory material. This is specially important in clone trial work when budding is done in the field on established stocks. When transplanted budded stumps are used this point is less important as preliminary sprouting of material can be obtained by nursery treatment and only plants at the same stage of sprouting are chosen for planting in the experimental plots.

Trans-planting.

Dormant Budded Stumps. The procedure found most profitable by the Ceylon Research Scheme is to impart a stimulus to the bud by ring barking the stock 8 inches above the bud patch 7-10 days before the root system is disturbed by transplanting. At transplanting the head of the stock is removed by a sloping cut 6 inches above the bud patch. The cut is waxed to prevent the loss of moisture. With small stocks these operations can be performed proportionately lower down. The stump is dug up with the root system as complete as possible ; and any unavoidable root pruning should not come within 12 inches of the stem, experiments in Ceylon and in Java having shown that such treatment results in the stumps getting away quicker than when the roots are trimmed. The roots may be dipped into a barrel of fairly thick liquid cow dung. There should be a minimum of delay in replanting. This method supersedes that of stumping the plant to 3 feet at time of transplanting and allowing stock shoots to grow for some weeks before cutting the plant back to force the bud into growth. The initial growth of the bud was then often delayed and sometimes dormancy of the stock persisted long enough for replacement to become necessary.

22

5, 24

20 Mann writes :—"Ring barking of the stock is certainly advantageous and can be recommended in districts where ample rainfall during a well-defined planting season is assured. In the monsoon rains of Ceylon and Java favourable conditions

may be depended upon with certainty. In Malaya, however, and to a great extent on the east coast of Sumatra, rainfall during the usual planting season, September to December, may be uncertain. Material for transplanting may be treated by ring barking in readiness for transplanting some ten days later. It is quite likely that when the time arrives for transplanting a large proportion of the nursery plants show plump buds, many may have shot, but local drought conditions quite unsuitable for transplanting may obtain. Result, the 'stimulated' plants continue to grow in the nursery and tender young bud shoots from the grafted buds develop to a stage when they are quite unsuitable for transplanting without serious risk of damage to the scion.

It is for this reason principally, that the most usual practice in Malaya is to bud in the field. It is customary to plant three or more seedlings at each tree point and by selection to reduce the number to two strong plants per point by the time budding is commenced (from 8 to 12 months from planting). One or both stocks may be budded (depending on supplies of first-class bud wood) and buddings made on well-grown established stocks are little affected by vagaries of rainfall, make excellent early growth and come into bearing relatively earlier than transplanted budded stumps. Surplus buddings are used to supply vacancies at all stages up to two years from the original budding operations and may also be used to provide bud wood for new areas or replantings."

3 In *De Bergcultures* an anonymous writer describes an occasion when a number of $1\frac{1}{2}$-2-year-old dormant, budded stumps developed a few weeks after planting necrotic patches on the bark at the point of union of stock and scion. A few trees died but the majority quickly recovered. The injury was finally attributed to sun scorch.

7 A somewhat similar injury is described from Indo-China.

24 Clonal differences are apparent in the length of time taken by the bud to shoot after cutting and transplanting the stump, in speed of growth when started and in the duration of time between flushes.

Opinion in Malaya on the advantages of budding in the field versus transplanting of budded stumps is divided. Generally the hilly estates, on rather dry quartzite soils, prefer to bud in the field; in the coast belt estates, on heavy alluvial clays which do not suffer in dry weather, very successful plantings with dormant budded stumps are often obtained.

6 Treatment of budded stumps by standing the cut ends of the tap root in the recommended dilution of a proprietary growth substance for 24 hours resulted in an acceleration of both root and shoot growth, and reduced transplanting losses. Similar results were obtained with unbudded seedlings.

20 *Basket Buddings.* In order to minimize the risk of loss from unfavourable conditions following transplanting a method of basket planting is being increasingly adopted in Malaya. Buddings in the nursery are pruned 2 to 3 inches above the grafted bud and the bud allowed to "just sprout". They are then carefully dug, roots severely pruned and transferred to rough wicker baskets 8 inches in diameter and 15 to 18 inches deep well packed with good surface soil. These basket plants are prepared about July and are packed in nursery beds in various vantage points in the area to be planted. Early growth of the scion continues in the nursery basket and as soon as weather conditions are favourable the vigorous young plants are transferred (complete with basket which decays quickly when buried) to their permanent points in the field.

22 *Stumped Buddings.* In this method seedling stocks are budded in the nursery, cut back to allow the bud shoots to grow, and transplanted to the field 18-24 months after budding when the scions are mature enough to be stumped in brown wood at a height of 6-8 feet. The method is often used in the work of the Ceylon Rubber Research Scheme, and no adverse results have been recorded. An experimental

planting was undertaken under this Research Scheme in 1936. Four hundred stumped buddings were planted out without failure and are growing well. The stumped buddings show a 6 months' growth advantage over dormant stumps and 12 months over seedlings. The plants have not yet reached tappable size. In raising rootstocks for this treatment it is advised that a liberal nursery treatment be given to build up the reserves on which the initial growth in the field so much depends.

20 Mann writes :—" This method of transplanting has also been used in Malaya and Java though not on a large scale. The advantages of the method are that in replanting the existing trees may be retained and exploited for an extra year (they give very high yields for a short period when tapped by specially severe methods), land may be gradually prepared and the early growth of the new material can be fostered under nursery conditions. In August 1938 I saw many hundreds of acres on the Government Plantations in Java which had been replanted by this method. The principal disadvantage is that decision regarding choice of clones must be taken three years before planting in the field takes place. In rubber selection work new and better clones, resulting from breeding work carried out in 1928-30, are just now being released for commercial use. Planters are reluctant to make their choice of material too soon in advance of planting."

Rootstocks. 10, 36 Seedling rootstocks of *Hevea brasiliensis* are used at present. The most usual age and size of the stock for budding is from 10 to 13 months or when the stock is 1 inch in diameter 4 inches from the ground. An objection to smaller stocks is that in the event of failure there is no room on the stock to make a second attempt. With stocks older than 2 years it is considered that the bark may often be too thick to work properly and that the bud patch will be less easily fitted and tied.

20 In Java it is customary to bud on stocks 18 to 24 months old. The stronger the stock, within reasonable limits, the better the growth of the scion in the " maiden " year after transplanting as a dormant budded stump.

Although seedling *Hevea brasiliensis* is the commonly used stock and, from the ease with which it can be procured, probably will always be in general use, the claims of other varieties are from time to time investigated.

31 From Sumatra come good reports of the performance of seedlings from the cross *H. Spruceana* × *H. brasiliensis*, the first named being the seed parent. Three different clones budded on seedlings of this cross were three years after budding, i.e. by 1938, of larger girth and producing a 25 per cent. higher yield than the same clones budded on *H. brasiliensis*.

Further experiments on the use of " clonal seedlings " as stocks, i.e. seedlings grown from the seeds obtained from buddings of well-proved clones give promise of very interesting results, which may support the findings in Sumatra with seedlings of clone AVROS 163.

21, 30 *Rootstock Influence.* The existence of a degree of stock influence may be accepted, though the results obtained by investigators have so far not been put to much practical use. In Java, for instance, the clones A.V.49 and A.V.50 give higher yields on A.V.163 stock than on any other, even than on the stocks of their own clone. The clonal seedling A.V.33 yields the same as the clonal seedling A.V.163, but A.V.49 and A.V.50 when budded on A.V.33 give lower yields than on A.V.163.

20 The Annual Report of the Rubber Research Institute of Malaya for 1938 contains accounts of tapping experiments on sets of twin plants, one plant being budded, which throw further light on the influence of scion on growth of stock and on relationships between yield of scion to yield of stock.

17 Double working has been suggested as a means of supplying a high yielding clonal bud with a top more suitable than its own. It is thought that, provided the new top is sufficiently highly placed on the tapping or intermediate stem, it would not

adversely influence the latex yield, even if such top came from a low yielding clone. The influence exerted would be probably nutritional. The first experiments (1928, in Java) were started with the object of giving high-yielding, susceptible clones a mildew-resisting top. A tree which sheds its leaves very gradually and is thus always in leaf rather than one which denudes itself within a few days was required. The most suitable clone with this characteristic was L.C.B.870, a clone of such low yield as to be unsuitable for normal budding. The results of this experiment are not given. Other ways in which a top scion could be useful would be in imparting vigour to a weak-growing high yielder, improving resistance to drought, repairing brittle, high yielders broken by the wind, or supplying tops of such a growth habit as to reduce shade and so allow the cultivation of coffee beneath.

11, 12, 15, 28 Stock influence on growth of scion is, according to Cramer, fairly pronounced. Experiment showed that fast-growing stocks resulted in fast-growing scions, while a slow-growing stock always resulted in a backward tree. This is confirmed

21 by Murray in a reference to some so far unpublished experiments in Java in which the controls and subjects were twinned, i.e. longitudinally bisected in the seedling stage and grown on separately. Whenever the unbudded member of a pair was vigorous the scion on the budded twin was vigorous also, and *vice versa*. Cramer believes that only these vigorous stocks should be budded and that it is better to abandon the nursery when they are used up rather than to bud the backward plants at a later date. Van der Hoop says that the influence of stock on girth increase of scion is less marked than that of scion on stock.

11, 12, 15, 37 The number of latex vessels in the stock is independent of those in the scion but is related to the growth rate of the scion.

32 Schweizer considers there is a definite mutual stock/scion effect which can influence yield as well as growth and describes a number of experiments in which both stock and/or scion influence are manifested. The degree of communication between latex vessels of stock and scion varies with different stocks and he attaches much importance to the vertical fusion of the latex vessels of stock and scion. The greater the number of vertical fusions allowing a clear run through of latex between stock and scion, the better will be the yield. Nevertheless, at present a stock should not be expected to increase the yield but rather to maintain it at a high level.

21 Murray, however, considers from experimental work at Peradeniya that there is no advantage in budding onto seedlings of the same clone, since any benefits due to affinity of tissues would be outweighed by other factors.

24 Some observations made by Ostendorf are as follows :—The degree of thickness of the stock does not shorten or extend the period between the insertion of the bud and its starting into growth. The length of this period seems to be a clonal

26 characteristic. The number of latex vessels in the stock is increased by the process of budding, independently of the specific properties of the clones. The number of latex vessels of the stock is independent of that of the scion. The degree of compatibility between stock and scion can exert a considerable influence on the yield capacity of both.

21 Murray has summed up the rootstock position as it stands at present as follows :— 1. In the case of some clones the scion may exert an influence on the yield of the stock, but this is of limited practical importance. 2. There is undoubted evidence that the stock can influence the rate of development and the yield of the scion growing upon it. 3. The effect may be of the order of at least 30 per cent., which is a matter of considerable economic importance, and becomes more marked as the tapping cut approaches the union. 4. It is probable that some clones are more susceptible to stock influence than others. 5. The properties of the stock to which this influence may be attributed are :—(*a*) vigorous growth ; (*b*) high productive capacity ; (*c*) compatibility with the cortical tissues of the scion.

An ideal stock, therefore, would be one which grows vigorously, which would develop a high yield if it were not budded, and which has been shown to co-operate well with the particular clone to be used.

Scion Influence. Scion influence on stock may be pronounced. Cramer describes experiments in which common seedling stocks budded with slow-and fast-growing
11, 12 clones had their girths at soil level respectively smaller and greater than those of unbudded stocks. The stocks budded with slow-growing clones took $7\frac{1}{2}$ years to attain the girth reached in $4\frac{1}{2}$ years by those budded with fast-growing clones.

15, 24, 26 According to van der Hoop the rate of girth increase of the stock is greatly influenced by that of the scion. The productivity of both stock and scion is largely determined by influences emanating from the crown of the tree and
21 travelling downwards across the union. Since other experiments have given contradictory results it is safest to assume that only certain clones have an appreciable effect on the yield of the stock. Thus in high-budded plants the scion *may* stimulate the yield of the stock and has done so up to 60 per cent. increase. The number of latex vessels of a seedling stock may increase after budding with certain clones, independently of the number of latex vessels in those clones.

Tying. The tie commonly used has been already described (*see* Budding, p. 57). Another method known as the garotte is successfully used on large stocks. A ring of
23 wire is placed round the trunk just above the budding point. After the bud patch is inserted the ring is slipped down over the lip, a strip of protective bamboo is placed between the wire and the bud and the ring is then tightened by the insertion of a wedge between it and the stem at the back of the stock. The method can be speeded up by providing the wire ring with a loop into which a metal skewer can be inserted and twisted till the desired pressure is reached. The position of the loop is over the bamboo strip on the lip. Advantages claimed are a great saving in material and time. The obtaining of adequate pressure is an essential factor to success.

23 In experiments in Indo-China the best results were obtained in those tying systems in which the pressure was about 4 kg. per cm. (57 lb. per square inch approx.).

20 A simple modification of the garotte system for use on small stocks is widely used in Malaya. A strip of coconut frond consisting of a section about 4 inches long by $1\frac{1}{2}$ inches wide containing the medium vein of the frond is placed over the budding panel after insertion of the bud and bound in position with cheap native twine or thin strips of "rotan" or split cane.

Criticizing a suggestion that the use of waxed calico ties increases cost and may be a source of fungal rot Mann writes that in Malaya "waxed calico is not an expensive item; for ordinary nursery work the bandages used cost approximately one penny per dozen (with care they may be used more than once, but the labour of cleaning and refolding hardly pays for the economy). Dangers of fungal rot owing to included moisture are much exaggerated. We have found the presence of water is generally due to faulty technique, thus the water results from decay of the damaged tissues beneath the bandage, due to incorrect binding (too tight) or slipping of the cambium surfaces—inexpert work in most cases." Care should
36 be taken to see that the calico when bought contains no dressing or it will be
20 necessary to wash it. Mann further writes:—"Rubber tape makes excellent binding material and strips made from old cycle inner tubes (and from motor-car inner tubes for large stocks) have been used in Malaya for many years. However, the expert Chinese budder invariably reverts to the waxed calico bandage, and more recently to the coconut frond and string tie method, in contract work or when he is working on his own holding. When budding must be done in unfavourable seasons, i.e. when there is danger of heavy rain, we use the rubber strip tie with excellent results. On the whole, the cheap tie used once and discarded is

preferable to more expensive ties which have to be collected, cleaned and the return checked."

36 In Java the leaf of *Musa textilis*, from which manila hemp is made, is used. The soft pithy part is scraped from a freshly cut leaf and the remaining layer is torn into strips of the required width. The material is soft and pliable and by contracting slightly on drying keeps the wrapping tight. The ventilation of manila hemp is so good that losses through moisture are practically nil.

29 The Rubber Research Scheme in Ceylon have had satisfactory results with thin vulcanized rubber strips under tension. This strip gives efficient protection against moisture, it can be applied rapidly and cleanly, since it is not sticky, and the same strip can be used a number of times. Arrangements have now been made for making this budding strip by extrusion.

Cuttings. 8 In Java Bobilioff has rooted *Hevea* cuttings by the following method. Young seedlings were selected having two pairs of leaves with a completely lignified internode. A piece of thin wire is twisted tightly round this internode so as to cut into the wood. This causes a swelling to develop above the ligature. After about three weeks the shoot is cut off below the swelling and planted in sandy soil under glass. One half of each leaf is trimmed off. Rooting should have begun about three weeks later. It is claimed that plants grown by this method develop very strong root systems.

6 *Growth Substances.* Preliminary experiments have recently been made with growth substances by the Rubber Research Institute, Malaya. Cuttings taken from the basal part of the main stem of one- and two-year-old seedlings showed marked stimulation after treatment, the number of cuttings rooting being greatly increased. Leafless hard wood cuttings from the main stem of one- and two-year-old buddings and one- to three-year-old branches of budded trees showed no response to hormone treatment. The production of new roots on root cuttings was facilitated by suitable hormone applications. The results of the treatment were the same whether the cuttings were set in closed propagators or in sandy beds under shade in the open, except that the rate of unfolding of the buds was markedly quicker under glass. The cuttings used were 15-18 inches long, cut obliquely at the base, not necessarily at a node. The most successful rooting medium was a fairly coarse-grained sand.

Marcots. 11 *Hevea* can be made to root without much difficulty by means of marcots. The roots so produced, however, may fail to anchor the tree firmly and trees so grown will not stand up to high winds.

4 Arens, in 1921, mentions that three out of four estates planted with marcots gave excellent results. The trees were tappable 6 months earlier than comparable trees from stumps planted at the same time and the yield was higher. (The stumps were from seed.) On the fourth estate the trees fell or slanted, which is attributed to unsuitable soil conditions. Photographs of the root systems of marcots show many strong laterals from which a few small verticals descend. Occasionally a marcot will develop a good vertical root system.

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IPOMAEA BATATAS Poir. (*Convolvulaceae.*) Sweet Potato.

Slips. 1

The rooted shoots arising from tubers closely planted in nursery beds are pulled off and transplanted to the field. When pulling the slips the tubers should be held down with one hand to prevent dislodgement from the soil. After well watering the tubers should produce another series of slips for transplanting.

Fifty-six pounds (one bushel) of tubers should produce 3,000 plants which (in Western Australia) will plant one-third acre.

Cuttings. 1, 2, 3, 4

These consist of sections of the vine stems 12-24 inches long containing 3-5 joints planted to half their length. Rooting takes place very readily.

In Western Australia the cutting recommended consists of three joints and a leaf at the upper end, one joint and the leaf being left above ground. Experiments in the Philippines resulted in apical cuttings usually proving superior to middle or base cuttings, starting earlier and giving a higher yield. The base cuttings gave the lowest yields.

Tubers. 1

Pieces of tuber containing an eye may be planted. The method is not usual.

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IPOMAEA PURGA Hayne. (*Convolvulaceae.*) Jalap.

Cuttings. Cuttings of side shoots set in sandy soil under shade and kept moist.

Stem Cuttings. Cuttings may be taken of the underground stems and planted a few inches below the surface.

Tubercles. The small tubercles may be planted but without delay or exposure to the sun after lifting.

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JATROPHA CURCAS L. (*Euphorbiaceae.*) Physic Nut.

Cuttings. 1, 2 Cuttings, 3-6 feet long, grow without any difficulty.

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LAWSONIA INERMIS L. (*Bythraceae.*) Henna.

Cuttings. Usually grown from seed but in some countries cuttings taken from plants purposely left unpruned are preferred.

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LECYTHIS spp. (*Lecythidaceae.*) Sapucaia Nut.

The nut produced by this tree is reported to be superior as an edible nut to the Brazil nut, *Bertholletia excelsa* Humb. & Bonpl. Both belong to the same natural order.

The introduction of several varieties of *Lecythis* was attempted in Malaya but *L. Ollaria* L. alone made any appreciable growth. Even so it has taken 8½ years to fruit, having reached in that period a height of 36 feet from about 2½ feet when first planted.

Cuttings. Cuttings have rooted in ordinary shaded beds in small percentages and would probably root freely in special propagators.

Marcots. So far marcots have only callused without rooting.

Etiolation. The etiolation method of layering is still in the experimental stage.

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LEUCAENA GLAUCA Benth. (*Leguminosae.*)

This tree is useful in plantations requiring a light shade and a leguminous green manure, since it provides both. The seedless variety is preferred in Sumatra and Java (whence all information in this section is derived) for the reason that

ordinarily the seed-bearing trees are so prolific that the foliage and shade are diminished. In Java planting distance is approximately 12 feet by 15 feet.

Budding. 3

Patch budding by the modified Forkert method is the usual method, with certain modifications. It can only be performed during the dry season, bud wood and stock being unsuitable in the wet season. Three or four days before budding the stock is partially girdled by the removal of a narrow ring of bark from three-quarters to four-fifths of the stem circumference at a point three-quarters of an inch above the proposed point of budding, usually about 2 feet from the ground. The bud patch is peeled from the wood. Should the heart of the central eye remain on the wood, the bud patch can still be used as the side buds will then develop. The raffia tie is removed 14 days after budding and the stock may be cut back a month later to half inch above the growing bud. Should the bud fail to grow, the stock is fully ringed by the completion of the original girdle and three or four days later another bud is placed opposite the defunct one.

Ten days after the removal of the tie from the supply bud the stock may be cut back. If for any reason two bud shoots develop, the weaker should be removed. At least 60 per cent. of successful takes can be anticipated.

Budded plants are ready for transplanting, if necessary, when the stem of the growing bud is half an inch thick at the point of union. The shoot is then cut back to a height of 4-5 feet, stripped of leaves and side branches and planted as a stump.

Grafting. 1

Splice (whip) grafting may be expected to give over 80 per cent. success if done in the dry season. Wet season grafting may reduce this success by as much as 50 per cent. Provided the work is carefully done, very young stock and scion combinations of, say, matchstick thickness give 50 per cent. Principal points to observe are :—the scion must match the stock for size and age of wood and fit accurately ; the grafts must be handled gently as they bruise easily ; the stock should be cut back to 1 foot in height two days before grafting, another 4 inches is removed at time of grafting ; in dry weather the stock should be watered two days before planting ; the scion should contain two or three buds but be not longer than 5 inches ; the tie should be made with some soft thickish woollen material and should not be too tightly put on ; the top of the scion must be waxed, or it will dry out ; the completed graft must be protected by an oiled paper, tubular covering (glass tubes are not satisfactory). The grafts are temporarily shaded with palm thatch for about three weeks or until the union is firm.

In dry weather the new grafts must be watered. Fourteen days after grafting it is advisable to remove the adventitious shoots, which will by then be sprouting on the stock.

Scion Wood. 1, 3

Scions should be made from mainly dark brown to grey wood or from the younger greenish-grey twigs obtained from the crown of the tree and of pencil thickness. Water shoots can also be used as scions, being suitable when the stem is brown to brownish-green. The crown shoots when used as scions continue to grow more or less laterally and have less inclination to form upright (and therefore less shade giving) growth. The low branching is inconvenient but it should not be impossible by selective pruning to induce a growth habit which will provide lateral growth at a sufficient height. Water shoot scions will continue their erect growth and are to be preferred. These can be obtained in quantity and in suitable condition for use by decapitation or hard cutting back of the parent tree or by making a number of saw cuts in its stem about three months before the scions are needed.

Rootstocks. 1, 3

Rootstocks of ordinary seed-bearing *Leucaena* are raised from seed in nursery beds made 3 feet wide and about 18 inches apart, these dimensions allowing easy access to the grafters. The beds should not be far from a water supply. The seed is laid in the beds, the spacing being about 6 by 6 inches. Five months from sowing

the plants should be fit to graft, i.e. of pencil thickness and 6 inches high. Self-sown seedling plants from the plantations can also be used as stocks after transference to nursery beds and have the advantage that a certain amount of selection is possible. For budding the stocks may be up to 3 years old and trees of this age can be treated in the plantation.

Cuttings. 1, 2 — Cuttings of the older wood from half to three-quarters inch in diameter and about 1½ feet in length have under very favourable conditions and with careful treatment produced a maximum success of 57 per cent. Of younger and thinner cuttings only 4 per cent. rooted. The method is not regarded with favour in Java. In the Philippines cuttings 3 and 4 feet long furnished 1 and 2 sq. yards of shade respectively in 18 months.

Layers. 1 — Whether ringed or not, layers have not succeeded.

Marcots. 1 — No success has been achieved.

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LONCHOCARPUS spp. (*Leguminosae.*) Cubé Root. Haiari Root.

The varieties at present cultivated are *Lonchocarpus Nicou* DC. grown on a large scale in South America and presumed to be the richest in insecticidal properties, 2 *L. chrysophyllus* (black haiari) and *L. Martynii* A. C. Smith (white haiari). *Lonchocarpus* spp. are under trial in Malaya by the Department of Agriculture who have kindly supplied details of propagation. The South American export cubé root is a serious market competitor with derris.

Cuttings. 3, 1 — Cuttings 12 inches long, of strong mature wood, will root under shade. It is usual to plant them in a slanting position in sandy soil.

In Malaya a suitably shaded site was secured by planting between the rows of mature bananas. Rooting should begin in a month's time and the plants be ready for transplanting in 6 weeks.

Layers. 3 — White haiari, a rambling shrub, also propagates easily from branches pegged down and covered with soil at the point of contact with the ground.

References

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2 Georgi, C. D. V. 1937. The toxic content of haiari or cubé root. *Malay. agric. J.*, 25 : 334-7.

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MACROPIPER METHYSTICUM Hook. & Arn. (*Piperaceae.*) Yangona.

Cuttings. — The plant supplies the kava of Polynesia. Sections of mature stems bearing nodes are rooted in nurseries and transplanted to the field when a few inches high. An increasing practice in commercial plantations is to lay the sets in prepared hills on their permanent sites and shade with a wisp of grass.

Reference

Parham, M. A. 1935-6. Wilt disease of yangona (*Macropiper methysticum*). *Agric. J. Fiji*, 8 : 2-8.

MANIHOT UTILISSIMA Pohl. (*Euphorbiaceae.*) Cassava. Tapioca.

Cuttings. 3 4 Cuttings are made of sections 4-10 inches long of mature woody stems, the actual length being a matter of local custom. Parts near the base and the herbaceous tops are discarded. The cuttings are set on their permanent sites either almost horizontally and just below the surface or vertically or obliquely, according to local preference, leaving about an inch exposed.

The stems can be cut into lengths of 5 or 6 feet and stacked upright in bundles in a cool dry place until required. Cuttings so treated will keep for several weeks.

4 Experiments in the Belgian Congo with setting positions for unrooted cuttings resulted in oblique setting being preferred to horizontal and vertical.

1, 5 Objections to vertical setting are the possibility of inversion by careless workmen, the result of such inversion being to reduce the yield of the plant by 60 per cent., to produce a great quantity of shoots useless for cuttings and to increase the toxicity of the poisonous varieties.

Vertical cuttings, too, have necessarily to be inserted more deeply in the ground.

6 Van der Zijl's experiments, three times repeated, show a reduction in root production of 6·5 per cent. when setting depth is 6 inches instead of the regulation 2 inches while the yield of starch is diminished by 13·2 per cent.

Objections to the horizontal method are that it leads to the production of a large number of stems which are too thin to be made into cuttings and make the plantation difficult to cultivate.

In the oblique setting found most favourable in experiments the angle with the underside of the cutting and the ground is a very acute one to minimize the effects of inverse planting. The cutting is inserted 2½ inches in the soil with about 2 inches protruding above ground. When the plants are knee-high they are

2 lightly headed back. Cuttings should be taken when the crop is lifted and the wood is ripe and at rest. It has been experimentally shown in Madagascar that taking a large quantity of cuttings when vegetation is active or when it has begun to decline will result in a serious reduction in the starch content of the plants supplying the cuttings.

Experiments in Madagascar show the most profitable spacing to be 0·80 by 1·60 m.

References

1 Bolhuis, G. G. 1939. Omgekeerd geplante stekken van cassave [Cassava cuttings planted inversely]. *Landbouw.*, 15 : 141-51.

2 Francois, E. 1938. La manioc. Sa production et son utilisation. *Rev. Bot. appl.*, 18 : 533-75, 682-707.

3 Greenstreet, V. R., and Lambourne, J. 1933. Tapioca in Malaya. *Gen. Ser. Bull. S.S. and F.M.S. Dep. Agric.* 13, 1933.

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MARANTA ARUNDINACEA L. (*Marantaceae.*) Arrowroot.

Rhizomes. 1, 2, 3

The upper ends of the tuberous rhizomes are cut off and planted. These contain little starch and are therefore of little value for manufacture.

The Acting Superintendent of Agriculture of St. Vincent (Mr. C. K. Robinson) has provided the very complete account of propagation in that island which is quoted below.

4

"Arrowroot is one of the staple crops of the island, and as such is grown continuously on the same land for several years as a quasi-ratoon crop, and the type of planting material depends on whether it is a plant or a ratoon crop. When a fresh piece of land is being planted all parts of the rhizomes are used as planting material, i.e. a rhizome is broken up into bits, each two or three internodes long and these are lightly covered over with soil to a depth of about three inches. The bits—actually the planting material goes by that name locally—are placed approximately six inches apart as it has been found that a wider spacing results in a reduced yield—closer spacing would probably produce a greater yield, but the amount of planting material required would be too great to be economic. When a field of arrowroot is mature—this is indicated by the drying of the foliage—the crop is reaped by digging up the rhizomes from the soil by manual labour, using hoes for the purpose. In general, the rhizomes are concentrated in the top nine inches of soil and with the loose volcanic ash soils of St. Vincent it is a comparatively easy matter to remove the rhizomes from the soil. Each labourer ploughs a narrow furrow about six feet in length and nine inches to one foot in depth, and into this furrow all the green and dried vegetable matter derived from the tops of the arrowroot and from weeds, are hoed in from a distance of about six feet ahead of the digger. The latter then proceeds thoroughly to dig up this cleared space, removing all rhizomes from the soil and throwing them on the surface of the soil just behind him. The replanting of the field is at the same time performed by breaking off the proximal end of each rhizome (three to four inches long) and dropping this in the furrow. The head of the rhizomes, by which name the proximal end is locally known, has rather a low starch content, and as it produces quite vigorous plants, the buds usually being well developed, it would obviously be the most suitable part of the rhizome for use as planting material. Such ratoon fields are usually supplied one month or six weeks later and on this occasion the process is exactly the same as in the original planting."

Shoots. 2

Young shoots may be detached from the parent plant and rooted.

References

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3 Redgrove, H. S. 1932. Arrowroot. *Food Manuf.,* 7 : 78-9.

4 St. Vincent, W.I. 1938. Communication from Acting Superintendent of Agriculture.

METROXYLON spp. (*Palmaceae.*) Sago.

Offsets and Suckers.

Metroxylon Sagu Rottb., the smooth-leaved, and *M. Rumphii* Mart., the rough-leaved sago, can be propagated by means of offsets or suckers. The mortality among the detached offsets is, however, high and the greatest care is necessary.

Reference

Fairweather, J., and Yap, S. T. 1937. The sago industry in Malaya. *Malay. agric. J.,* 1937, 25 : 329-33.

MYRISTICA FRAGRANS Houtt. (*Myristicaceae.*) Nutmeg.

Budding. 4 — The high proportion of male and hermaphrodite trees to females among nutmegs render some form of vegetative propagation desirable, especially as the sex cannot be determined till the trees are several years old.

In Java, after unsuccessful attempts throughout the year, the nutmeg was successfully budded in some quantity by the modified Forkert method in December 1934 during the rains. The stocks were year-old seedlings of *Myristica sucedanea* Blume, half-inch in diameter. Much of the difficulty seems to arise from the rapidity with which the bud dries out. In the successful cases the bud wood was soaked for a day in water before use. Immediately the bud was inserted, low down on the stock, it was shaded by a long tube of banana leaf sheath. The raffia tie was loosened after twenty days and the stock cut back to within 8 inches of the bud a week later. The buds began to grow out in two months.

Bud Wood. 4 — The bud wood was taken from half-ripened, unpetioled wood, the strong buds of water shoots giving the best results.

Grafting. 1, 3 — In recent years young seedling stocks in pots have been grafted by approach onto thin twigs of female trees at the Jamaica Botanic Gardens. Approach grafting was tried in the East Indies in 1848 or even earlier. The unions were apparently sound and the plants grew well laterally but no leaders were produced.

Cuttings. 2 — Cuttings of small lateral shoots with heel inserted under hothouse propagating conditions in a compost of 90 per cent. sand, 10 per cent. leaf soil, have rooted fairly quickly at the Royal Botanic Gardens, Kew.

References

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2 Kew. 1938. Curator, Royal Botanic Gardens. Correspondence.
3 Oxley, T. 1848. Some account of the nutmeg and its cultivation. *J. Ind. Archipel. and E. Asia,* 2 : 641-60.
4 Postma, A. 1934-5. Voorloopige mededeeling over het oculeeren van nootmuskaat [Budding nutmeg]. *Landbouw,* 10 : 450-2.

PAULLINIA CUPANA H.B.K. (*Sapindaceae.*) Guarana.

Cuttings. 2, 3 — The natives of N. Brazil, where the plant is cultivated, propagate it mainly by cuttings, but in what manner the authorities available do not state.

1 — When grown in gardens under glass for ornamental purposes the cuttings are taken from young shoots in early spring and rooted in a closed propagating frame.

References

1 Bailey, L. H. 1927. *Standard cyclopedia of horticulture.* Macmillan, New York and London.
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3 ——— 1935. Abstract of 2, *Rev. Bot. appl.,* 15 : 49-50.

PELARGONIUM spp. (*Geraniaceae.*) Geranium.

The essential oil of commerce is derived from varieties of *P. Radula* L'Hérit. and possibly *P. graveolens* L'Hérit. or their hybrids. The strains do not come true from seed.

Cuttings. 1, 2 — In Kenya the most suitable cuttings are taken 12 inches long from nearly mature wood with short internodes. This ensures a stocky growth. Softer wood will also root but the first growth then tends to be prostrate. The presence of the

terminal bud in a cutting seems to be immaterial provided a few leaves are left. Cuttings will strike in nursery beds of light soil but sand beds give less risk of fungus attack which may be severe. In suitable localities the unrooted cuttings may even be planted direct into the field. The cuttings should be made with a sharp knife rather than with secateurs. In the Belgian Congo terminal cuttings 10-12 inches long from fairly mature wood of the current season are preferred. Older wood gives a high percentage of failures. Cuttings are planted 2 inches apart in shaded beds of light soil and in a month should have rooted sufficiently for transplanting.

References

1 Beckley, V. A. 1937. Essential oils. Geranium oil. *E. Afr. agric. J.*, 2 : 287-91.

2 Lejeune, J. B. H. 1935. Recherches sur la géranium rosat. *Bull. agric. Congo belge*, 26 : 379-87.

PIPER BETLE L. (*Piperaceae.*) Betel.

Cuttings. 2 Propagation is solely by cuttings. In Ceylon a cutting consists of three nodes and three leaves taken from plants not less than 1 or 2 years old. The main or leading secondary shoots are used. To prepare, the lowest leaf is removed just before planting, leaving half inch of leaf stalk ; the second leaf is raised vertically and rolled round the stem while the top leaf is wrapped round the second. The object is to conserve moisture. In planting, the cutting is set in the ground to the second node which remains at soil level. In about three weeks the leaves are opened in the evening but are tied up again in the same way three or four days later. In the north-east monsoon cuttings are planted directly into shaded permanent beds, at other times in sheltered nursery beds. Cuttings can be kept for a few days before use under shade and with a daily watering. Sometimes the seed of *Eleusine Coracana* Gaertn. is sown among the bundles and germinating quickly helps to keep them cool and moist. The supports are living *Erythrina indica* Lam. or *Moringa oleifera* Lam. according to district.

2 Cultivation is very specialized and methods vary with the locality. Two systems in use in Ceylon are well described by Paul and his collaborators.

1 In Malaya the cuttings are taken from 2-year-old plants, trimmed into lengths of 18 inches, each with five or six joints, and planted two joints deep in heavily watered beds under light shade provided by previously sown *Sesbania grandiflora* Poer which also serves to support the vines.

References

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PIPER NIGRUM L. (*Piperaceae.*) Black Pepper.

Cuttings. 4 Cuttings are taken from the tops of the bearing vine ; those from running shoots will not as a rule bear flowers. Cuttings from unisexual vines are preferable, care being taken not to include more than a small proportion of male vines. Usually those cuttings showing roots at the points are taken, but in any case roots will soon develop in the cutting bed. The general practice is to make the cuttings of some length, from 1 to 3 feet and to plant about 6 inches deep. Shorter cuttings take longer to form good plants.

3 In Java the cuttings are root-bearing top shoots 3 feet long and one-third inch thick, about 16 months old. All lateral branches and all leaves with the exception of the top two are removed.

2 The cuttings may be planted in nursery beds or direct into the field in which latter case three cuttings are inserted to each support which can be either a living tree, variety according to local custom, or hard wood posts or trellis. The comparative value of living or " dead " supports is still one for discussion. In a recent combined

1 manurial and support experiment in Malaya the yields were heavily in favour of the hard wood posts. In this case the living support was *Gliricidia maculata* H.B.K.

Layering.

4 In Sumatra at the beginning of the second rainy season after the first planting, the pepper plants are bent down and their tips buried so that only the arch of the stem is visible. The buried tip soon roots, thus increasing the feeding organs of the plants. From the arch spring several strong shoots which grow with great rapidity and fruit in the following year, thus effecting a great reduction in the time taken for productive yield under the usual methods.

References

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3 Ochse, J. J. 1931. *Vegetables of the Dutch East Indies.* Archipel Drukkerij, Buitenzorg. (English edition of *Indische Groenten.*)

4 Ridley, H. N. 1912. *Spices,* p. 258. Macmillan, London.

PISTACIA VERA L. **and others.** (*Anacardiaceae.*) Pistache.

Budding.

3, 4 Experiments with budding in Russia showed that the best time for budding was at the time of the second (or autumnal) growth from July to mid-August.

T shield budding with the wood removed from the back of the bud gave by far the highest percentage of success. Leaving the wood behind the bud in place lowered the percentage very appreciably. That the result of removing the wood at the back of the bud was a better and quicker union was confirmed by microscopic examination.

In California, where the cultivation of this crop is scientifically studied, dormant buds from the old wood inserted in April and May, when the bark peels easily, are very successful. The bud wood may be taken in winter and kept in cold storage until required in spring. The inverted T is advised in U.S.A. since it enables the gum exuding from the wound to flow away. Its adoption raised the percentage of success to 95 per cent. from 65 per cent.

In Syria the budding is done in July-August while the bud is in growth.

Grafting.

1, 2 Cleft grafting is a common method wherever the tree is grown.

Rootstocks.

The following have been used with more or less success as stocks. *P. atlantica* Desf., *P. chinensis* Bunge, *P. integerrima* Stew., *P. Lentiscus* L., *P. mexicana* HBK, *P. mutica* Fisch. & Mey., *P. Terebinthus* L., *P. vera* L., *P. verestina* (hybrid). Of these preference is given by some to *P. atlantica, P. mutica, P. Terebinthus* and *P. vera.* *P. chinensis* from its hardiness and vigour seemed indicated as a suitable stock for *P. vera.* The scion, however, in the first year or two often overgrows the stock to such an extent as to render the tree top heavy. A year or two later the stock overtakes the bud and growth proceeds normally. The stocks are worked in U.S.A. in nursery rows when one year old and are planted out at one year

from budding or one or two years if from seed. Their large tap root makes it unsafe to delay planting beyond this age. Grafted or budded trees bear in the fourth year.

Topworking. 1, 2, 3 Branches of male trees are often grafted into female trees to ensure pollination. In Russia when it was desired to convert about 1,000 acres of wild pistache trees (species not stated) rind grafting was chosen after experiment as being the method giving the best results. The scions were shoots of the current year.

Cuttings. 4 In Russia stem cuttings are said to root in nursery beds.

References

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4 Zhigarevitch, I. 1939. Vegetative propagation of the pistache. (Russian, 7 line English summary.) *Soviet Subtropics,* No. 6 (58), pp. 27-30.

POGOSTEMON HEYNEANUS Benth. (*Labiatae.*) Patchouli.

Cuttings. 1, 2 Propagation is by cuttings of semi-mature stems rooted in shady beds.

References

1 Grist, D. H. 1936. *An outline of Malayan agriculture.* Dep. Agric. S.S. and F.M.S.

2 Nicholls, H. A., and Holland, J. H. 1929. *A text book of tropical agriculture.* Macmillan, London.

PSYCHOTRIA IPECACUANHA. (*Rubiaceae.*) Ipecacuanha.

Cuttings and Layers. 1, 2 Cuttings or layers from mature plants. Any broken piece of the annulated roots will grow. A well-drained, humus soil, a moist atmosphere and a sheltered position are necessary. It is usual in Malaya to strike the cuttings in boxes containing a mixture of sand and humus, planting them out when rooted (in about 6 months) 12-18 inches apart in raised beds.

References

1 Grist, D. H. 1936. *An outline of Malayan agriculture.* Dep. Agric. S.S. and F.M.S.

2 Nicholls, H. A., and Holland, J. H. 1929. *A text book of tropical agriculture.* Macmillan, London.

PUERARIA PHASEOLOIDES Benth. (*Leguminosae.*)

Marcotted Cuttings. *Pueraria phaseoloides* has been asexually propagated in Ceylon. Selected shoots consisting of fairly mature stems were enveloped near the base in a mixture of good earth and cattle manure kept in place with pieces of sacking, preferably old manure bags. Rooting had occurred in 4-6 weeks when the rooted stems were detached and planted out. The experiment took place early in the rainy season.

Reference

de Silva, C. A. 1937. Notes on the propagation of *Pueraria phaseoloides. Quart. Circ. Ceylon Rubb. Res. Scheme,* 14 : 16-18.

SACCHARUM OFFICINARUM L. (*Gramineae.*) Sugar Cane.

Cuttings.
4 Six-inch lengths containing two or three joints from the upper part of the cane are planted 5 inches deep, with one inch projecting, in ploughed furrows or in holes. The average distance apart, which varies according to country, soil and slope, is 5 feet by 5 feet. As soon as these cuttings root and begin to send up other shoots from the base the original central piece (called the mother plant) should be cut out.

2, 1, 6 In Java deep planting up to 14 inches gives the best results especially on heavier soil. Actually, whether the cuttings are taken from the top, middle or butt of the cane has in the long run little effect upon yield, but the tops give a higher percentage of germination and therefore require less supplying after planting.

3 Length of piece also seems to affect germination, experiments with 10-, 3- and 2-eye pieces having given germination percentages in this descending order.

1 The upper portion of the flowered cane often produces sprouted buds or shoots (called lalas in Hawaii). These lalas taken off with a diagonal section of the node of the parent stalk can be used as planting material.
In experiments in the Philippines lalas gave a better percentage of germination than middles, as the result of better resistance to adverse conditions.

5 At the Philippine College of Agriculture desirable canes were most rapidly increased by planting split sections from the original plants. In five months these sections themselves produced suitable stems for propagation in a similar manner and the series could be continued indefinitely. Tillering from these plants averaged 4·3 per stool.

References

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SANSEVIERIA spp. (*Liliaceae.*) Bowstring Hemp.

Cuttings.
1 The most rapid method of propagation is by leaf cuttings of the whole or part of a leaf. The leaves are torn or cut from the plant and dried in the open under shade for from 15 to 25 days before setting in a sandy well-shaded bed.

Other Methods.
1, 2 Other methods of asexual propagation are by division or by pieces of rhizome.

References

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2 Nicholls, H. A., and Holland, J. H. 1929. *A text book of tropical agriculture.* Macmillan, London.

SCORZONERA TAU-SAGHIZ. (*Compositae.*)

A native of Central Asia and able to withstand great extremes of heat and cold, *Scorzonera Tau-Saghiz* is now under cultivation in Russia for the rubber producing properties of its roots. It has been found to react strongly to climatic conditions differing from those of its centre of origin and thus to offer considerable facilities

for the plant breeder to establish types suitable to the requirements of cultivation and industry.

Root Cuttings. Vegetative propagation is easily accomplished by means of root cuttings, or more simply by allowing the broken roots left in the soil when lifting the plant to renew growth, which they will do even though at a considerable depth.

Reference

Legros, J. 1937. Secondary rubber yielding plants of the Caucasus region in Central Asia. Int. Rev. Agric. (*Mon. Bull. agric. Sci. Pract.*), Rome, 28 : 468T-81T.

SOLIDAGO spp. (*Compositae.*)

The *Solidago* species referred to here are *S. Leavenworthii* and *S. serotina* Ait., plants under investigation in Russia for the production of rubber.

Division of Roots. Dividing the plants when more or less dormant has the merit of speed and certainty but the number of plants so reproduced does not exceed 20 per stool.

Cuttings. Cuttings present a rapid method of propagation. These are taken 3-4 inches long as green shoots or with one to three eyes if root cuttings are used. The root system in both these varieties is well developed. The operation is carried out as quickly as possible, careful attention being given to watering and shading. Transplanting is possible in 25 days. In Florida a good plant will provide 500 cuttings ; in Russia the average is about 200, a figure which it is hoped to increase by means of plants especially grown for propagation.

Reference

Legros, J. 1937. Secondary rubber yielding plants of the Caucasus region in Central Asia. Int. Rev. Agric. (*Mon. Bull. agric. Sci. Pract.*), Rome, 28 : 468T-81T.

SMILAX spp. (*Liliaceae.*) Sarsaparilla.

The drug sarsaparilla is obtained from the root of several species of smilax.

Cuttings. Cuttings of the shoots will root with ordinary care and produce crops quicker than plants raised from seed.

Suckers. Suckers arise freely from the rhizomes. These can be detached with a portion of root and planted out, preferably in rainy weather.

Layers. Layering consists in spreading out the vine shoots on the ground and lightly covering them with soil, pegging them down where necessary. Shoots so treated will root freely.

Reference

Nicholls, H. A., and Holland, J. H. 1929. *A text book of tropical agriculture.* Macmillan, London.

THEA SINENSIS L. (*Ternstroemiaceae.*) Tea.

Budding. 2, 7, 17, 21, 26 In Java tea is budded by the modified Forkert method. The stocks so treated may be 1½-2-year-old nursery plants or older trees already in bearing (*see* Top-working p. 81). In nursery budding the stock, which should be not less than one-third inch in diameter, is cleaned of twigs and leaves to about 4 feet from the ground to admit of circulation of air in the closely planted beds. The buds used are those just beginning to grow. At the Tea Research Institute, St. Coombs, Ceylon, dormant buds are used. The wood at the back of the bud shield is not

removed and care must be taken to see that it is cut to lie flat on the stock. To achieve this, stock and scion wood should either be of the same diameter if small, or both be fairly large so that their curvatures approximate. Should the wood, however, accidentally become detached and the central bud injured, it has been found that the dormant secondary buds at the side will grow and the bud need not necessarily be discarded. Often with undamaged buds on a vigorous stock five or six shoots may spring from a bud, thus giving the possibility of rapid formation of a frame. To guard against rain infiltration the tie is wrapped from below upwards and the bud is allowed to protrude between the folds. In Ceylon where dormant buds are used the bud is completely covered by the raffia tie. Strips of rubber cut from the inner tubes of cheap bicycle tyres were found efficient and waterproof ties but too attractive to the children of the labour force. After twenty days the tie is removed and about two weeks later the stock is cut back to 4 inches above the bud. Cutting back the stock at the time of loosening the tie is said to cause an excessive sap flow which may result in detaching the shield. Six to eight months after cutting back the stock the bud shoot should be about 3 feet high and the dead stub can then be cut out leaving about half an inch of dead wood, while the bud shoot itself, either then or earlier, should be headed back to the third joint. In sunny positions it is advisable to place the bud on the shady side of the stock.

The method described is reputed in Java to give a 90 per cent. take but tea budding to be successful requires care and attention to detail, and usually the take will be found well below this figure. An average budder should do 120-150 buds per day with normal bud wood ready at hand, but suitable bud wood is often difficult to

3 procure, owing to the small number of buds per shoot and the fact that bud wood must be from $1\frac{1}{2}$ to 4 years old (increasing with altitude). [In England two men working as a team with bud wood at hand would, if patch budding fruit trees, do about 500 per day and, if shield budding, nearly double that number.]

7 An earlier investigator, Keuchenius, thought that no tree under 5 years old should furnish bud wood, and that the eyes should be completely dormant. Keuchenius, however, was not particularly successful, his experiments in budding resulting as follows :—rectangular patch 8 per cent., T shield budding 2 per cent., Forkert method 2 per cent.

9 At the Tea Research Station, Georgia, U.S.S.R., budding experiments in the field on stocks which, through scarcity, were of various qualities and ages, produced the following results :—

(*a*) T shield budding, one-third of the leaf blade being left on the bud, 53 per cent.
(*b*) T shield budding without leaf blade, 33 per cent.
(*c*) As (*b*) but with earth mounded round the point of insertion, 41·7 per cent.
(*d*) As (*b*) but with wood at back of bud removed, 5·3 per cent.

9 Kvarazkhelia, who was engaged on this investigation, considers that with good stocks, on which the bark will separate easily from the wood, and with well developed buds taken from well-developed summer shoots, 70-90 per cent. of successful buds should be obtained.

Stocks over 3 years old are seldom suitable owing to the condition of the bark. In Ceylon on unplucked or unpruned bushes the bark always slips easily except at the height of the short dry season. The bark on plucked or pruned bushes is often very difficult to peel even under favourable climatic conditions.

25 Some recent observations from Java on the results of experiments with budded tea are of interest.

The percentage of successful takes remained the same whether the bud wood was from the same stocks, which in this case were young plucking bushes of known yield, or from different clones. After budding there was a decrease in yield of 20 per cent. (as between stocks worked with own bud wood and unbudded stocks of the same origin) which lasted until the first pruning. It was due to the small

number of shoots required to build up the frame of budded plants, averaging 2·5 against 8 with unbudded plants.

In a total of forty-eight pluckings extending over 17 months the five best clonal buddings out-yielded the unbudded plants by 31-48 per cent. and the self-budded plants by 63-83 per cent., while the average yield of all the forty-three different budded clonal varieties was also higher than the self-budded or unbudded plants. By the use of these high-yielding clones the loss of yield from budding to first plucking with average material was eliminated. There appeared to be a marked stock influence on yield, nevertheless the scion influence is always predominant.

Grafting.

7 Keuchenius mentions some very low percentages obtained with tea grafts on young stocks (for his work with older stocks *see below* Topworking). These are:— veneer grafting 3·7 per cent., T shield grafting 2 per cent., cleft grafting 4 per cent., splice (whip) grafting 0 per cent., crown notch grafting 0 per cent.

10 At the Research Station in Georgia, U.S.S.R., about 1934, grafting in the field by the insertion of scions in a T incision in the bark of stocks of (unavoidably) various qualities and ages was tried. Success percentages were as follows :—

(*a*) Green scion with two eyes and half leaf, 52 per cent.
(*b*) The same without leaf, 0 per cent.
(*c*) Green scion, single eye, no leaf, 40·5 per cent.
(*d*) Green scion, three eyes, no leaf, 26 per cent.
(*e*) Brown scion with half a leaf (and presumably two eyes), 18 per cent.
(*f*) The same as (*e*) without a leaf, 2 per cent.

The grafts were bound with raffia but not waxed. For winter grafting stocks were transplanted from the field to heated glasshouses and planted in sand. The successful grafts were planted outside in the spring. Grafting wax is used in winter grafting. Results * were :—

(*a*) Bench grafting, 76 per cent.
(*b*) Saddle bench grafting with tongue, 61·5 per cent.
(*c*) Bench grafting with tongue but without a leaf, 41 per cent.
(*d*) Bench grafting, leaf reduced to half, 40 per cent.
(*e*) Bench grafting on roots, 31·5 per cent.
(*f*) Bench grafting with two saddle-shaped ledges, 30 per cent.

15 At the Tea Research Institute, Ceylon, single node cuttings were successfully grafted onto a rapidly growing radicle of a freshly germinated seedling. The graft is tied with cotton and at once plunged into moist, but not sodden, peat moss until union takes place. After union the plumule is cut off from the seedling leaving the reserves in the cotyledons to assist the early growth of the graft. The cotyledons when exhausted are removed by trimming off the whole of the stock just above the point of union with the scion, as otherwise shoots start in the axils of the cotyledons.

3 The advantage of grafting is that twice a year numerous scions can be cut from a single bush. In Java with both crown and side grafting 60 per cent. success is considered high.

Topworking.

By Budding.

2, 4, 6, 7, 11, 16 In Java the trees to be worked are, if possible, well-grown bushes pruned two years previously, of any age up to ten years but having a soft and pliable bark. They are cut back hard and all the smaller branches removed a few days before budding, leaving only the shortened main branches. Cutting back six months before budding was not very successful when experimentally tried. The buds are placed (using the modified Forkert method) one each on the outer sides of the remaining branch stubs at a height of about 6 inches from the ground or, if only the main stem is to be used, as low down as possible. The remainder of the technique is similar to that already described under tea budding in Java. Seed bearers are difficult to bud on their old branches since the bark will not peel,

* The exact meaning of the following grafting terms is not clear.

but if cut back and budded on the resulting shoots they give good results. They can, however, be grafted. Topworked plants can be plucked two years earlier than ordinary replacements. The percentage of success in the field is about 20 per cent. lower than that obtained with nursery budding. Two years after budding close to the ground a seed plantation in Java the trees so treated had reached a height of 15 to 17 feet.

7 *By Grafting.* Experiments in rind grafting tea were made in Java by Keuchenius in 1923. Certain factors are mentioned by him as having important bearing on success :—(1) the provision of adequate shade for two months after grafting ; the covering of the whole scion with the exception of the bud with grafting wax ; (2) compatibility of stock and scion, incompatibility being by no means uncommon ; (3) the stage of development of the scion buds ; the best results, 76 per cent., were obtained from scions on which the buds had grown out to about half the length they eventually reach before unfolding ; scions with buds in the dormant, swelling or in the pekoe stage gave about 55 per cent. ; (4) diameter and age of scion ; thin scions produced 29 per cent. success, medium 53 per cent., thick 62 per cent. ; (5) scion length, which should not exceed $3\frac{1}{2}$ inches; short internoded scions with two eyes gave very much better results than longer-internoded scions of similar length bearing only one eye ; (6) diameter of rootstock ; the stock diameter of $1\frac{1}{2}$-3 inches is the most successful one ; (7) age of the parent trees from which scions are taken, in this case 13 years ; scions taken from trees in bloom gave 23 per cent. and from trees of similar age cut back $2\frac{1}{2}$ years previously to $4\frac{1}{2}$ feet 61 per cent. ; (8) the most successful period began 14 days after the first rains of the rainy season had fallen, though at the actual time of grafting the weather must
17 be dry and preferably cloudy. Dr. Tubbs of the Tea Research Station, Ceylon, suggests that the importance of the supply of carbohydrates, either present in the graft when inserted or manufactured by its leaves subsequently, requires determination. Under Ceylon conditions starch accumulation in the stems is comparatively rare.

6 *By Rind Graft.* The rind grafting of cut-back 2-year-old shoots on stumped trees is another way of topworking, but the delay necessary for the shoots to reach grafting size may be inconvenient. The tree to be worked over is decapitated $1\frac{1}{2}$-2 years before it is required. A year after the cutting back four of the strongest of the resulting shoots placed more or less equidistant round the stump are selected and the rest eliminated, no others being allowed to grow. The selected shoots should be stripped of side branches for a foot from their junction with the main stem. One to three days before grafting the stock shoots are cut back square 6 inches from the stump. If this is not done in advance, excessive bleeding may swamp the scion and cause it to rot or the bleeding may break through the wax covering. The optimum diameter for the shoots to be grafted is one-half to three-quarters of an inch. Young nursery plants 2 years old (or $1\frac{1}{2}$ years in lowland districts) may be rind grafted though less successfully. In this case the crown is cut off 9 inches from the ground and the graft placed directly on the stem.

Rootstocks. At the Tea Research Institute, Ceylon, *Camellia japonica fl. pl. alba* has been
22 successfully inarched onto tea seedlings. The reverse graft has not yet been
15, 23 tried. In horticulture the garden varieties of *Camellia japonica* are regularly used with success as rootstocks for other *Camellia* spp. At this station a collection of plants botanically related to tea is being made with a view to finding a stock
24 which will hasten the fruiting of seed bearers. Some experiments by Wellensiek with nursery-raised stocks of equal age, classified from diameters at 2 inches above the ground into thick, medium and thin, gave the best results in percentage of takes for the thicker shoots. The thicker stocks also produced a more rapid and vigorous growth in the buds placed on them. The selection of the best stocks only for budding in the nursery beds is, however, uneconomic. The use of seed

with a high specific gravity and the early selective thinning of newly planted nursery beds is helpful in obtaining sturdy stocks from seed.

4, 25 *Stock Influence.* At present little is known about stock influence in tea, but signs are not wanting that it exists.

Stem Cuttings. Experiments were carried out at the Tea Research Institute, Georgia, U.S.S.R., with many types of stem cuttings with the aid of greenhouses and solar propagators
10 or even in frames over an ordinary hot bed.

At times the conditions in the houses and propagators were unsatisfactory, with fluctuating moisture and temperature, a rooting medium of seaside sand insufficiently washed and sterilized and a personnel inexperienced and frequently changed. For these reasons considerable fluctuation in rooting percentages were obtained from different batches of similar type. Rooting percentages obtained from some of the experiments are given below.

Green or half-ripened wood :—

(*a*) Four eyes and all leaves, 31-46 per cent.
(*b*) Three eyes and all leaves, 48·5-65 per cent.
(*c*) Three eyes and one leaf, 54 per cent.
(*d*) Two eyes and all leaves, 38 per cent.
(*e*) Two eyes and one leaf, 42·5-59 per cent.
(*f*) One eye green cuttings with one leaf, 54·5-62·5 per cent.
(*g*) Single green buds cut as for budding with one leaf, 35-58·5 per cent.

Brown mature shoots of the current season not older than one growing season :—

(*a*) Four eyes and all leaves, 66-70 per cent.
(*b*) Three eyes and all leaves, 55-56·5 per cent.
(*c*) Three eyes and one leaf, 63-80 per cent.
(*d*) Two eyes and one leaf, 44·5-62 per cent.
(*e*) One eye with all leaves, 44·5-62 per cent.
(*f*) Single brown leaf buds cut as for budding with one leaf, 33·5 per cent.

Cuttings older than the above root less readily, the percentage of failures increasing with the age of the wood. In the case of semi-hard wood cuttings, the younger
17 the shoot of the current year's growth the less is the chance of success, plucking shoots with three leaves being the least useful. Tubbs considers that the failure of plucking shoots to root is due to the high demand for carbohydrates made by the expanding leaves which cannot easily be satisfied by increased light, if trans-
10 piration is to be kept sufficiently low. Mallet cuttings with leaves, from 2-year-old wood, rooted better (19-27 per cent.) than similar cuttings without the mallet. Heel cuttings of 2-year-old shoots with leaves gave a higher percentage, 23·5-32, than similar shoots without heel. Heel and mallet cuttings were not tested with younger than 2-year-old wood. Cuttings of all types from which the leaves had been removed gave very poor results. If conditions were not favourable, a tea cutting would callus but not root until suitable conditions were established. Such cuttings remained alive for 6 months or more, in Ceylon for over 18 months, provided soil moisture and temperature did not fall below a certain minimum. In Russia on the establishment of optimal moisture and temperature these cuttings
17 would subsequently root. This was not the case in Ceylon even when the callus was pared. Here in cases where the base of a single node cutting dies, roots may grow from the stem higher up the internode ; normally the roots are produced in a bunch at the bottom of the cutting.

There was no difference in the vigour of the root system or in the amount of shoot growth between plants from cuttings or even from single eyes and plants of similar age grown from seed. Tubbs in Ceylon agrees with this but adds that cuttings frequently produce two or three shoots from a single eye after they have become established, in distinction to the single stem of seedlings. This is in many cases an advantage. The addition of a good supply of humus to the pot compost or to

the nursery beds was found to have a profound effect in increasing the amount of lateral growth of cuttings.

18 Tunstall in Assam, 1931, obtained a fair percentage, 53 per cent., of success with soft wood cuttings of terminal shoots. The rooting medium was a loose fibrous soil and the cuttings were kept under glass in a saturated atmosphere till rooting
13, 20 took place. These experiments repeated in 1932 at Buitenzorg, Java, were quite unsuccessful, but in 1939 van Emden and de Haan had better fortune. In a
3 glass covered and shaded propagator, in which the temperature was kept at 75-82° F. and the light intensity to from 5-10 per cent. of that of the open, and with a rooting medium of well-drained river sand, in 12 weeks banji shoots rooted 98 per cent., peko shoots 49 per cent., single-internode cuttings 57 per cent., three-internode cuttings 57 per cent. None had died during the period. Trials with the root growth auxin β-indolyl-acetic acid showed 80 per cent. increase of rooting when the stem bases were immersed for 36 hours in a solution of 100 mg./l., and 10 per cent. in 50 mg./l. for a similar period. A 16-hour immersion at either strength was ineffective, as was the application of the auxin in lanoline paste. Hard wood cuttings have been rooted successfully on a tea estate near Nagoda in Ceylon, and specimens were sent to the Tea Research Institute, Ceylon. They are photographically illustrated in the Institute's publication, *Tea Quarterly*, 1932, 5 : 4 : 154.

17 There are distinct clonal differences in rooting ability of cuttings, particularly
15, 16 when sand is the rooting medium. When peat moss is used the difference lies more in the amount of root produced per rooted cutting in a given time than in the number of plants rooted.

24 Wellensiek in Japan saw woody cuttings, cut with three buds, successfully rooted in nursery beds and planted out a year later. He thinks that both variety and climate must influence success, in view of the difficulties experienced in other
17 countries. As Tubbs points out, the difference in methods of propagation finding favour in various countries is remarkable, but it will be remembered that these countries range from tropical and sub-tropical to what in the case of Russia is a
24 temperate climate with a real winter season. Wellensiek also describes a method (locale not stated) in which single buds with a leaf and a short piece of stem were used. They were cut under water to exclude air, planted in coarse sand under glass in a temperature of 71° F. and humidity 99 per cent., the latter maintained by hourly spraying, and subjected to four hours' artificial light after sunset. The buds showed great individual differences (from 0 to 45 per cent.) in ability to root, even between members of the same seed family, but there were no differences
17 between Assam hybrid types. Dr. Tubbs now informs us that the method was one originally tried by him in Ceylon. He has since modified it as follows :— " Mature green stems and stems which have become red but have not formed a thick bark are selected. Full mature leaves on green or slightly reddened stems are best. The age of the leaf is of moment ; young leaves wither and old ones drop off and the importance of maintaining an adequate leaf surface has been demonstrated. The bud in the axil may have started to grow before the cutting is made ; in this case it should be pinched back to the first fish leaf from the stem. The stems are cut with a sharp knife above a sink of water into which the cuttings fall. The cuts may be made under water and this was originally done, but the easier method seems quite satisfactory. The cut is made just above each mature leaf so that a single node cutting is formed consisting of bud and leaf at the top with a very small stump of stem above the point of junction of the bud, and below an internode length of wood. These are inserted into fine peat moss, made and kept pleasantly damp but not sodden. Care should be taken not to cover the bud so deeply as to exclude light from it. The cuttings are kept under moist humid conditions, with as much light as is feasible whilst still attaining moist conditions, for three months, after which they may be gradually hardened off.

Between four and six months a sufficient amount of roots will have been formed to permit of planting out in the field. The great advantage of the peat moss is that unlike sand or grit frequent waterings are not required to maintain a satisfactory humidity, while the roots that are produced bind a compact mass of peat moss together. With careful lifting this mass may be transferred uninjured to the field. Unless the cuttings have previously been hardened off to withstand full light, loss due to sunscorch may occur at this stage. The use of a heavy shade of cut foliage which is gradually thinned obviates this and permits of successful establishment in the field. The use of peat moss has been found to have great advantages over the use of a coarse sand or grit, among these being easier control of humidity, very much better and quicker rooting, and a smaller tendency to form large masses of callus at the base of the cutting. Clones which have proved entirely intractable in sand have been very easily rooted in peat moss. The use of peat moss has enabled the extension of propagation by cuttings beyond the limits of frames and plant houses. I am now propagating cuttings in beds of peat moss 5 inches deep, shaded by coarse cloth spread over wire netting, with satisfactory results so far. When single internode cuttings are inserted in the open like this, however, a light mesh of netting or similar material should be laid across the leaves after insertion as high winds are liable to whip them from the peat moss. As yet it has not been shown that this method is sufficiently cheap to permit of large-scale propagation of cuttings on a commercial basis, but no difficulties have been encountered which would suggest that it is not perfectly feasible to propagate clonal areas of sufficiently large size for all experimental uses by this method. For seed bearers, of course, where the value of the individual plant is higher, the method should be quite economic. In fact this is easily the most promising method of vegetative propagation I have yet obtained, as from one selected bush many hundreds of cuttings may be obtained at a time from which 60 to 90 per cent. success may be obtained. Cases of 100 per cent. success are not unknown." Under Ceylon conditions it is important to start cuttings at the beginning of the rains. They can then be hardened off in the fine weather following the rains, by which time they will be well rooted.

24 Wellensiek, 1932, mentions certain conditions which appear to assist the rooting of hard wood tea cuttings. The cuttings should be left three or four days after removal from the tree before planting ; they should be set on a slant rather than erect ; they should be thick rather than thin and those on which the buds are beginning to grow are better than those on which the buds are entirely dormant. Under these conditions 78 per cent. of rooting has been obtained, but 30 per cent.

17 may be considered normal. Tubbs considers the uncertainty of success with hard wood tea cuttings to be due to lack of reserves in the wood. In tea the reserves are almost entirely in the roots.

19 Wellensiek, following a method used at East Malling, also tried, 1931, the effects of etiolation by earthing up stumped trees, and detaching and planting the etiolated shoots as they came through. Shoots so treated rooted in 30 days after removal but not with the vigour of ringwired shoots rooted on the stump (*see* Stooling, below). The roots emerged along the stem and not through the callus. Treatments with various reputed root-forming solutions in Ceylon were inconclusive.

10, 17 *Transplanting*. Rooted cuttings were either potted for a time before being put out in the field or else temporarily transplanted to nursery beds. The latter system resulted in fewest losses, less than 10 per cent. When young rooted cuttings were transplanted direct from the rooting medium to the field the losses reached 60 per cent.

17 In this connexion Tubbs writes :—" When the rooting medium is peat moss much of the material remains on the roots and thus losses at transplanting are greatly reduced." He continues, " One of the great snags about transplanting is that, at least under our conditions, the change in the rooting medium leads to the death

of all the younger roots, e.g. transplanting rooted cuttings from sand to peat moss under conditions in which the rooting of unrooted cuttings occurs quite successfully leads to the death of the fine roots and therefore to a considerable check to the growth of the plant. Similarly transference from peat moss to water culture or from sand to soil leads to a similar death of the young rootlets, new fibrous shoots being produced from the older rootlets. This, I believe, is one of the advantages of transplanting with a ball of peat moss enclosing the majority of the roots, as new rootlets grow out into the soil and become adapted to local conditions as they grow. It may be noted that the same thing happens when two-year-old seedlings are transplanted from the nursery to the field under commercial conditions."

Root Cuttings.

10

Experiments were carried out at the Tea Research Institute, Georgia, U.S.S.R. The cuttings were obtained by uncovering the roots and removing the required pieces or by digging up the plant and cutting up the roots into pieces 3-4 inches long, the number of cuttings per bush ranging from 20 to 160. The roots and cuttings were set in the open 8 inches apart in well tilled soil supplied naturally with adequate moisture. Weeds were kept down by occasional hoeing and there was no watering. Cuttings set out in May or June rooted in two months. Results were as follows :—Thick root cuttings, diameter over three-quarters inch, 52-75 per cent. success ; medium cuttings from half to three-quarters inch diameter, 37-45 per cent. ; and thin cuttings, under half inch diameter, 9·5-18 per cent. Under optimal conditions of soil and moisture cuttings under half inch in length rooted just as easily as the longer ones. Cuttings set horizontally at first developed a surface root system while roots of vertically planted cuttings ran deeper. In both cases, after two or three years, a number of horizontal roots changed their direction and grew vertically downwards. Root cuttings were also obtained by uncovering portions of the roots of growing plants. The uncovered portions would produce shoots in great numbers the same summer. These shoots with pieces of root attached could be separated from the parent and transplanted. The method on any large scale is weakening to the parent tree. The frequency

17

of producing shoots from exposed roots is, according to Tubbs, strongly influenced by the jât of the plant. At the Tea Research Institute, Ceylon, altitude 4,500 feet, 286 root cuttings set in grit in an outdoor frame had failed to root after six months.

Layering.

13

In Formosa it is the custom to layer tea in order to maintain the characteristics unchanged. The ground round the bush is first loosened, the branches to be layered are then bent down, twisted sharply at their points of origin, fixed to the ground by bamboo pegs and covered with soil, except for the green top. In six months the young plants are ready for removal. Tea of the China jât type roots more readily than the Assam jât. In experiments with this method of layering at the Tea Research Institute, Ceylon, omission to twist or nick the layer at the point where rooting was desired reduced the percentage of success very considerably.

25

In Java layering is found easy but slow when the rapid propagation of a single clone is in question.

9

Continuous Layering. In Georgia, continuous layering was nearly 100 per cent. successful. The whole shoot is pegged down into a trench 4 inches deep and about 3 inches wide. The internodes of the shoot are covered with earth while the nodes remain uncovered as also does the shoot tip with from three to five leaves. The shoots which spring from the nodes produce roots and are ready for transplanting at the end of the season.

Simple Layering, in which the base of the shoot was pegged down just under the surface and its shoots held upright with vertical pegs, gave about 80-90 per cent. success, which was slightly increased by previously wounding the shoot at point

of contact with the ground and was unaffected by the application of potassium permanganate. Rooting is established in 2-3 months. Hedges are quickly formed by pegging down the branches along the rows and so forming a continuous series of layers which grow into a thick hedge connecting the parent trees.

Layered tea appears to root with remarkable ease, the roots of layered plants being both nodal and internodal, and, should the collar of the tree be covered by too deep planting, then roots will be produced along the buried stem above the
17 collar to soil level and the tree does not suffer. Tubbs writes :—" This is very common in Ceylon where pruned bushes have become covered with spoil earth from the cutting of drains or cart roads. Where such branches produce a mass of fibrous roots, as they frequently do along their buried length, one is very inclined to try to multiply the bush by sawing off the rooted branches which may be from ½ to 1½ inches in diameter. I have never succeeded though, the stem always dying back. Whether this is due to sheer obstinacy or to that mysterious reason ' the physiology of the bush ' I have yet to find out."

The degree of success in layering depends on the age of the shoots and the maintenance of an adequate soil moisture. Rooted layers transplant much more readily than seedlings owing to their superior root system, which should be allowed time to develop freely before severance of the layer. Artificial aids such as ringing, nicking or wiring assist rapid root development.

22 This pegging down method was tried in Java. It corresponds to the etiolation method used at East Malling for the propagation of certain fruit tree stocks. Of 119 layers, 43 died quite early, and of the 76 that were alive a year later only four had produced rooted shoots. The Russians in Georgia (*see above*) claim from 90 to 100 per cent. success by this method ; they, however, only cover the internodes and leave the green extremities of the shoot above ground.

In Ceylon it has been found that if the light is cut off from tea shoots by earthing over they do not grow and the rooting of the stem appears to be inhibited.

Stooling.

7, 9, 22 Stooling was tried in Java in 1922 with the sucker shoots from previously stumped trees. The shoots were girdled to a width of three-quarters inch, about 2 inches above the ground, and earthed up to a depth of 4 inches. The method was more successful than that of the pegged down layers in that about 94 per cent. had
20 rooted well in 9 months, but none survived transplanting. Wellensiek, 1932, in Java reports 100 per cent. success with ringwired shoots from stooled plants, 8 months being required for all to root. In this case the ringwire was not put on till the shoots were reddish-brown at the base. Both stooled nursery plants and
22 bearing plants were used with equal success. It seems to both Wellensiek and Tubbs that the longer the rooted layers are left on the parent plants the more successfully they transplant later. When two years old these clonal rooted shoots can themselves be stooled and a stock thus quickly worked up. By way of experiment a number of stooled shoots were stripped of their leaves when earthing up ; none of these rooted, while 80 per cent. of the controls had done so in 2 months. Similar results were obtained in Ceylon. A number of the stripped shoots were allowed to grow leaves and 75 per cent. of these then rooted, while the shoots deprived of their leaves still remained unrooted. Placing two extra rings above ground on the shoots already ringed below reduced the rooting percentage very
12 considerably. In Malaya, stooling combined with ringwiring was successful. In this experiment the ringwire was not put on until the earthed shoots had become blanched, for which purpose the soil had to be first drawn away and subsequently replaced. In U.S.S.R. the method was equally successful and the transplanted trees did not perish.

9 An even simpler method of mounding was tried in Georgia. Low-branching bushes 2-3 years old were earthed up so as to cover the basal portions of the lower growths. These rooted to the extent of 87 per cent. and ringing or wiring the shoots did not improve on these results.

14 At the Tea Research Institute, Ceylon, it was found that rooting was more ready when the stools were mounded at an early stage before the red-wood stage at the base of the new shoots is reached, but not before the buds break on the stump of the parent bush. Ringing was not practised.

Twinning. 13, 15 Identical pairs of plants can be obtained by splitting seedlings which have germinated to the point where stem and root are discernible, in such a manner that one cotyledon remains attached to each section. The halves so formed grow and develop normally. If it is desired to divide the seedling up into a larger number of pieces the attempt should be made before the radicle is more than 5 mm. long. Plants so treated must be set in peat moss and kept in a saturated atmosphere until re-established.

Marcotting. 7, 9 Keuchenius in 1925 made experiments in marcotting as also did Kvarazkhelia in U.S.S.R. in 1934. The best marcots were 2- to 3-year-old sucker growth springing from stem and branches of bushes previously cut back to produce them. The most suitable shoots were about an inch thick 8 inches from their junction with the main stem. The time to operate is when the trees are in full growth ; marcots made then should be ready for planting out 10 months later. To prepare the marcot a ring of bark about 1 inch wide is removed from the stem just below a lateral shoot (which is cut off) or a leaf. The cambium on the wood in the wound is destroyed by scraping with the back of the knife or by rubbing with a piece of sack. If this causes roughness it is better to discontinue it. Leaves and side shoots which are in the way are pared off. The container consists of a jointed section of bamboo 4 inches in diameter and a foot in length. This is split lengthways, notches are cut in the transverse wood of the node, which forms the bottom of the container, sufficient to take the stem of the marcot when the two split halves of bamboo are fitted together. The container so made is fitted over the prepared marcot and firmly tied to prevent leakage and drought. The ringed portion of the stem should be midway up the bamboo cylinder which should be now filled with loose soil or leaf mould, lightly compacted when half full and again when full. The soil must not be tightly packed. To avoid any movement of the cylinder which might inhibit rooting it should be firmly attached to a side branch. When the rooted plants are to be severed from the parent tree the leafy tops are cut back to about 1 foot from the top of the bamboo and the upper part of the roots is also trimmed. The marcot is detached from the parent at the point of union with the main stem. Successful transplanting is not so easy as in the case of stumps, and shade and moisture are required for a year. The growth of bush green manures between the rows was found of advantage if the loppings were mulched on the surface of the soil.

Inarching. 14, 15 There is no difficulty in inarching tea provided stock and scion are in suitable condition. At the Tea Research Institute, Ceylon, it was found that the effect of age on rapidity of union was most marked. Green tissues unite in about 10 weeks, mature stems may require nearly a year, while semi-ripe or red wood holds an intermediate position. The grafts should not be severed for at least 3 months or the supply of water to the scion from the roots after planting out may be inadequate. The seedling stocks are best at 4-8 months old and should be well established in pots of compost containing a good supply of well-rotted cattle manure, and be in active growth, since quickness of growth accelerated the union considerably. Should scion material be scarce it is possible to inarch almost

7 every bud on the scion shoot to a different seedling rootstock. Keuchenius in Java in 1923 obtained 98 per cent. success.

17 Bearing tea can be inarched to neighbouring bushes and so hasten the producing of a large supply of material for cuttings or for the production of bud wood.

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THEOBROMA CACAO L. (*Sterculiaceae.*) Cacao.

1, 2 The earliest recorded propagation of cacao by vegetative methods occurred in Trinidad in 1898 when Mr. J. H. Hart, then the curator of the Botanic Gardens, was successful in inarching onto seedling stocks.

The subsequent work of investigators in various parts of the tropics is concisely summarized by Cheesman in a historical note, with which he prefaces his article on vegetative propagation of cacao.

Budding. Two types of bud may be used. Those from fan branches, which will continue
3, 5 to grow out laterally, and those from chupons or watershoots which will produce an erect growing shoot. Patch budding is used in Trinidad, the bud being taken from half-ripened wood of a brownish-grey colour. It appears to be immaterial whether the position selected on the stock is the site of a bud or not. The bud may shoot within a few days of application or it may be delayed. The tape can be removed in from 7 to 14 days, the latter for safety. The stock of pot plants is cut back to one or two leaves as soon as the bud shows signs of sprouting, and later is cut back to the bud. In ground plants the preliminary light heading back can be omitted and the stock be cut hard back, provided the bud patch has united well with the stock, in fact the buds often will not start until the stock has been
4 cut back. A method used in Java to secure speedy starting is to bend down the stock in the form of an arc by attaching the top to the base of a nearby plant or by a peg to the ground.

3, 5 De Haan, however, in Java says that cutting back should not be done till the new bud has grown 2 feet and is of finger thickness which will be in 3 or 4 months after budding. Careful attention to detail will increase the percentage of success. Plants grown in bamboo pots are liable to become starved through nutrient deficiency or to suffer from lack of water. Such conditions must be prevented or they will seriously affect the percentage of success.

13 Attention has been called to the frequent progressive deterioration in yield and general health of budded cacao which sets in about the twentieth year. Suggestions have been made that this too-early senescence is due to the progressive effect of some small stock/scion incompatibility which had its origin at time of budding. To avoid this ultimate breakdown budding (it is claimed) should only be done when stock and scion are each in full vigour, i.e. at the beginning of a flush. Stock and scion must be of the same age at point of insertion. Similarity in colour of the bark is, however, no criterion. Older stocks therefore may have to be budded higher than is usual but this is actually beneficial with cacao. Many failures to unite and much stock/scion incompatibility is attributed to low budding (i.e. on old bark with young bud wood). Union between stock and scion should be complete in 20 days. Any bud which has not begun to grow out within one month after loosening the tie should be discarded, since, even though it may grow well when it does start, it will always have some internal flaw which sooner or later will make its presence felt.

5 *Bud Wood and Scion Material.* Three types can be distinguished : fan bud wood, large chupon bud wood, and small chupon bud wood, the latter usually being produced as a result of special treatment in the nursery. The bud is usually in its best condition for budding when the subtending leaf falls. A similar condition can be brought about with cacao as with other plants by cutting off the leaf about half way down the petiole. The remainder of the petiole will fall after

about 10 days and the bud will then be ready for use. The use of older bud wood is feasible but has certain disadvantages ; it may be long in starting owing to the primary bud being lost and the secondary bud still unformed, or the outer layers of the bark may contain parasitic fungi which may infect the wound. If the presence of fungi is suspected, immersion of the bud wood for from 3 to 5 minutes in a solution of from ½ to 1 per cent. formalin has been found to raise the percentage of takes from 17·5 to 75 per cent. Chupons for the supply of large bud wood, which must be used on large stocks, can be obtained by hard cutting back of the mother tree. Large stocks, however, are not always available and take longer to produce, though there appears to be no difference in yield between fan and chupon buddings. Chupon bud wood is desirable because of the superior habit of the resultant tree. The following technique has been evolved at the Imperial College in Trinidad to provide a supply of chupon buds which can be worked onto small stocks. Stools are established from rooted chupon cuttings, or from chupons derived from fan buddings cut hard back at about a year old. Another method, if only fan buds are available, which may also be quicker, is to bend down the stock, attaching the top to the base, and at the summit of the arc thus formed to insert a fan bud. In five cases out of eight in Trinidad the fan bud grew up into a chupon, though with a second experiment in which the fan buds were rather more advanced the percentage of chupon growth was much smaller. If plants established by any of these methods are kept hard pruned a constant supply of hard chupons with small buds will be available.

Bud wood will lose its viability quickly unless wrapped in a damp cloth or kept moist in some other way, and with all precautions will gradually deteriorate, so that a lapse of 24 hours between the cutting of the bud wood and the insertion of the bud will appreciably reduce the percentage of success.

8 Small-scale experiments in Trinidad showed that plants raised from cuttings of fan material and therefore exhibiting the fan habit could be converted into chupon plants by ringing the stem a few inches above soil level or by ringing the stem in conjunction with hard pruning of the lower branches. Such chupons could then be either stooled or layered or removed and propagated as cuttings.

Stooling. 6 Suckers growing from the base of a tree, usually one which has been cut back to near ground level, will root if earthed up. From experiments in Trinidad it appears that the roots thus produced are not enough to support the sucker if detached from the parent. If, however, previous to earthing up, a ring of bark is removed at the base of the sucker or the base is constricted with wire, strong root growth will develop above the ring.

Layering. 6 Seedling trees with their side branches removed, i.e. leaving only chupon growth, pegged down on the surface of the soil will develop erect chupon growth from the buds along the stem. After seven weeks these erect shoots are mounded up and in 9 months develop a strong root system. Layers which are lightly covered with earth before bud growth starts, as in the East Malling system with deciduous fruit trees, will not send out shoots.

Herbaceous Grafting. 10 Thierry gives the following rules for herbaceous grafting on young seedlings. The scions are taken preferably in the early morning from the vegetative tips of branches of the selected tree ; the exact stage is just after the leaves have lost their silky appearance and are taking on a green tint. The scion leaves are cut back to 2 cm. excluding the petiole length. The scion, in length from 2 to 3 inches depending on the length of the internodes, contains one or two eyes and the terminal bud, and is cut with the basal two-sided wedge extending for half its length. A downward cut is made on the left side of the stock at the axil of the cotyledon and the wedge is inserted and tied but not waxed. The scion, owing to its tenderness, must be preserved from all evaporation and should not be subjected long even to the heat of the hand. Immediately the graft is made it must be

placed under glass in a close humid atmosphere. Little air should be admitted till union starts, a sign of which is the cicatrization of the scar left by the fall of the truncated leaves of the scion.

Topworking. 5, 12 Attempts to renovate old trees by cutting them back and budding on the chupons which arise have been very successful, such buds making very rapid growth. There is, however, a tendency for such budded chupons to snap off at the junction with the parent trunk, unless they arise at ground level and form their own roots.

5 Pound mentions that he has seen an estate with several hundred trees successfully converted by this system.

Inarching. 10 Thierry's method of inarching young coffee seedlings (*see* Coffee. Inarching, p. 36) can also be applied to cacao and with less difficulty since the cacao plants of equal age are larger and more easily manipulated, but, whereas the coffee after this grafting needs no further immediate attention beyond shading, cacao must be temporarily kept in a closed, shaded frame with a high humidity.

Rootstocks. 3, 5 A stock of about lead pencil thickness is a convenient size for budding; such stocks are usually about a year old. They should be in full vigour and should, therefore, if in pots, be grown in fairly rich compost. Experiments in the manurial treatment of cacao growing in bamboo pots have shown that in these pots cacao is intolerant of any but very small quantities of inorganic salts at a time, i.e. as much as will cover a silver threepenny bit. The addition of inorganic manures weekly for a month before planting was of no apparent benefit, if the plants were already growing in a good compost. The rebudding of failures has seldom proved satisfactory unless done after the unsuccessful stocks have had a long rest and then results are only 50 per cent. successful. There is strong evidence that incompatibility of some kind can exist between stock and scion. Trials in Java indicate that the influence of rootstock on yield is considerable.

4 In Surinam *Theobroma bicolor* did not prove successful as a stock for grafting cacao. In from 2 to 4 weeks the buds died and fell off. *T. simiarum*, a native of Costa Rica, is suggested as a possibly suitable stock plant.

Cuttings. *Soft Wood Cuttings* (of half-ripened wood). The rooting of cacao from cuttings had never, until recently, been recorded though references to unsuccessful attempts had appeared from time to time.

2 In 1930, however, the investigators working under the newly inaugurated Cocoa Research Scheme in Trinidad made a serious and successful attempt to solve this problem. The stages by which the now accepted technique was evolved were

2, 6, 7, 8 described as the work progressed in the pages of the Scheme's annual report and in *Tropical Agriculture*. The perfected method is given below. Propagating frames are necessary. These propagators, which are not solar propagators and have no provision for additional heating, are 3 feet long by 2 feet 10 inches, with the back wall 3 feet above ground level and the front wall somewhat lower, and are constructed of concrete. A drainage hole is provided at the bottom. The bottom of the frame is filled with a thick layer of stones and gravel and covered with a layer of sand 6 inches deep. The surface of the completed bed is within a foot of the top of the frames. The frames are built back to back in two rows of six. The lights may be of glass or of calico stretched on a portable framework. The latter is preferable for ease of manipulation, though, as the calico develops mould, it needs occasional renewal. If glass is used it requires shading which can be provided by a double cheesecloth covering. Whatever type of shaded light is used, the frames receive an additional shade from a canopy of calico stretched on a framework of angle iron and wire and either projecting sufficiently beyond the frames to provide shade at all hours or with easily removable side curtains to east and west as a protection against the oblique rays of the sun. The

mean temperature within the frame is about 78° F. Cuttings for the production of clonal cacao are for preference taken from young budded plants specially grown in quantity for the purpose from the selected parent trees. This is more con-
2 venient than obtaining material from the field, since the exact condition of foliage, i.e. the first hardening of the young leaves from a new flush, is rarely available when required, if collecting has to be done at a distance. It is found that cuttings from medium-shaded trees root better than those from unshaded or lightly shaded trees. Cuttings from young unfruited trees seem to have an advantage over those from bearing trees, possibly, it is tentatively suggested by Cheesman and Spencer, owing to a lower C/N ratio. Cuttings in the necessary vigorous and firm condition can be taken from the budded plant when the shoots are about 4 months old. By delaying, however, until the budded plant is a year old and has branched, a supply of about six suitable shoots should be available. Cuttings taken in this manner are usually from fan or lateral branches and will develop this habit in growth. To produce the chupon growth from which erect growing plants are obtained the year-old budded plants are cut hard back to a few leaves or a lateral branch. At least one-fourth of the number of treated plants will subsequently produce chupon growth, though occasionally a second cutting back may be necessary.

The chupons themselves, if headed back, will branch into three or four more. If more rapid increase of chupon material is required the first chupons can be used as bud wood rather than as cuttings. The cuttings of either type, which are placed in water immediately on severance, may be from 9 to 15 inches long, the position of the slanting basal cut being apparently immaterial. In Trinidad, for convenience, it is made just above a node, if necessary removing the lowest leaves so as to allow a clear stem of at least 1½ inches, and the final basal trimming is always made just before insertion. It was found convenient for setting to trim back the leaves to half or one-third of their length. This is still a common practice with many plant propagators as a means of checking excessive transpiration.
9 Actually, however, provided a sufficient humidity is maintained to prevent wilting, the practice is, if anything, detrimental, in that it deprives the cutting of a portion of its assimilating surface. The cuttings are set about 4 inches deep in the coarse calcareous sand which has proved to be the best rooting medium. Thrips have proved troublesome and preventive control is now obtained by dipping the cuttings before setting and again before potting in a 1 : 500 nicotine solution with a trace of soap. The atmosphere within the propagating chamber must be maintained in a practically saturated condition and ventilation of the chambers is adequately supplied by the occasional opening of the frames for the purpose of spraying the plants. The optimum relative light intensity is probably about one-quarter to one-eighth.

Under the conditions outlined the average rooting time for cuttings is about three weeks, chupons taking rather longer than fans. About 90 per cent. of an average batch should root. When rooting starts the emerging roots of the chupon grow straight downwards while those of the fans spread laterally for a time, each thus reproducing the habit of its top-growth.

The rooted cuttings are potted into locally made paper-lined baskets (*see* Potting Baskets, p. 20) of the capacity of a six-inch pot, especially made for the purpose. These baskets are in every way superior to bamboo joints and are much cheaper than earthenware pots. The compost used consists of 2 parts loam, 1 part coarse sand, 1 part sifted cow dung. The potted plants are kept close in a propagating frame until root-growth has started which may take a week or more. They are then ready to be set out in the field nursery. The plant is set in the ground in its basket to about half the depth of the latter, the reason for this being that as the basket rots the soil within sinks several inches. Some temporary shade additional to that provided by the shade trees may be necessary.

Hardening off is not necessary as top growth as a rule will not have started till the plants are outside. If it does, usually from cuttings which were too woody when taken, an immediate introduction to light and air must be made so that the flush may harden as it develops.

6 *Hard Wood Cuttings.* In Trinidad callusing was obtained in a solar propagator but no root emergence.

Root Cuttings. 6 Root cuttings of various sizes failed to root in Trinidad.

Marcots. 3 Marcotting presents little difficulty. It has, however, been little used partly because it was thought that marcotted plants, being without a tap root, would be inferior in various ways to normal plants. De Haan, however, mentions a plantation in Java entirely composed of marcotted plants which bore well for many years.

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UNCARIA GAMBIER Roxb. (*Rubiaceae.*) Gambier.

Cuttings. 1, 2 Gambier is usually grown from seed. Nicholls, however, states that cuttings are preferable, but gives no details as to method.

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VANILLA spp. (*Orchidaceae.*) Vanilla.

3 Two species, *Vanilla planifolia* Andr. and *V. Pompona* Schiede, are cultivated for vanilla, the former being the more generally grown.

Cuttings. Cuttings from 1 to 4 feet in length are used, the length varying with the locality.

1, 2, 3 The shorter cuttings are in more common use, though they do not come into bearing until the third or fourth year. Long cuttings begin to flower in the first year. With these the stem is laid on the ground in a circle up to half its length or coiled round the support. The tip must be protected from the sun and the prostrate stem should be covered lightly with a layer of soil or rotten leaves. Short cuttings can be planted against the support on which they are to climb or in nurseries until rooted. At least two joints should be left above ground. Growth will start in a week or two and the plant will cling to the support. Nursery beds are of good rich humus soil shaded and watered as the season requires. The effect of drought or insufficient shade is to turn the leaves a yellowish shade.

Where root disease is prevalent the lower extremity of the cutting may be left dry above the soil, the two next joints above being lightly covered with the rooting medium. By the end of the second year the cuttings should have grown 10-14 feet. Ridley deprecates the practice of clean weeding the plantation. There is no doubt that the plants benefit from the shade provided to the roots by moderate weed growth. If weeds are objected to, then the ground round the plants must be kept mulched.

The cuttings will keep several weeks before planting if properly packed.

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ZINGIBER OFFICINALE Rose. (*Zingiberaceae.*) Ginger.

Rhizomes. The rhizomes, usually pieces from the old crops then being dug, are cut into small

1, 2, 3, 4, 5 "sets" or "bits" 1-2 inches long, each containing one to three eyes from which the new plant will grow. Larger bits are used if the soil is not of high fertility, but for curing purposes the planting of small sets is preferable to large "hands", experiments in Ceylon having indicated that the size of the set has a distinct influence on the eventual form of the hand. The bunches that develop from small sets are larger in size, much less bunched together and separate easily. Where seasonal planting is necessary and the stock rhizomes have to be kept for a time after digging, they are first allowed to wither, then washed, dried and stored on a bed of trash in a clamp rendered airtight by a covering of clay. Curing, i.e. withering for a month before the planting, is, in Jamaica, supposed to produce bolder and therefore higher priced ginger. There the bits are planted 9 inches deep in trenches 9 inches apart. The situation should be in full sun, shade-grown ginger having a tendency to shrink. In Jamaica and in Ceylon, 1,500 lb. are required

4 to plant one acre; in Ceylon, however, controlled experiments have shown 2,240 lb. per acre to be the optimum from a practical standpoint though expressed in terms of seed rates the yields show an increase with decreasing seed rate, i.e. 1 ton per acre 11-fold, ·33 tons per acre almost 20 fold.

5 A mulch of straw, about 4,500 lb. to the acre, has been found very effective in Ceylon in increasing the yield.

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